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14. ABSTRACT
This report summarizes the deliberations and conclusions of the 1998 Air Force Scientific Advisory Board (SAB) study on Information Management to Support the Warrior. In the study, the panel develops an enhanced concept for managing information for all echelons of command. A combination of continuing and leveraging the current information management programs/investment and overlaying the concept of Battlespace InfoSphere (BI) are identified in the report. The Air Force needs to get the right information at the right time disseminated and displayed in the right way so commanders and ("crew chiefs") can do the right thing at the right time the right way. The information must be provided without creating an information blizzard. When the Air Force does this faster than the adversary, the Air Force has information superiority. The emphasis of this panel was developing a BI concept for managing the information. The BI is the next step in the evolution from system-centric to network-centric through information-centric. The BI must support all levels of military operations, anywhere, anytime from a distributed base of operations such as command, planning, execution, information support, combat support. Information management processes enable the input, manipulation, and access of information. The major technologies and associated research/development projects at agencies throughout the government are sorted according to a variety of prioritization schemes. The panel sorted according to the following schemes, Air force priority, maturity, evolution, and capability of the technologies. Finally, the panel recommends the Air Force implement the Battlespace InfoSphere concept.

15. SUBJECT TERMS
ACTD, battlespace, Battlespace InfoSphere, C41, command and control, decision support tools, combat support, data fusion, fuselet, global awareness, information access, information grid, information management, information manipulation, network centric, sensors

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Executive Summary

The Requirement and the Challenge of Information Management for the Warrior

Commanders, warfighters, and other combatants require integrated, global awareness and mission understanding that enable real-time planning, control, and execution of the aerospace mission with a minimum number of people and equipment forward deployed to the area of operations. The specific need is for a Battlespace InfoSphere (BI) that can be tailored in size and geographical representation to meet the operational, maintenance, logistics, and other warfighting requirements of unified, subunified, combined, joint, and/or coalition operators. The BI must provide integrated mission understanding, shared awareness, shared planning, shared execution, shared visualization, shared support, and shared future view. The challenge is to provide the *right* information at the *right* time, disseminated and displayed in the *right* way, so that commanders (and “crew chiefs”) can do the *right* things at the *right* time in the *right* way. The objective: interpret information and make decisions faster than the other guy, thereby ensuring *information superiority*.

Today’s legacy systems provide much information to today’s combatant, but because the legacy systems are disjointed, there is an overload of poorly organized and incomplete data and little usable information. This means that cognitive effort that should be focused on the operation is being used to deconflict the data being presented. The inability to integrate information or view the operational problem from an information perspective requires the next evolutionary step toward a battlespace information system.

The Solution to the Information Management Challenge

The solution for this operational need:

- Continue the evolution begun by the initiative of network-centric warfare and leverage current information management programs and investments and new joint operational concepts.
- Build a BI for managing information compatible with network-centric warfare. As recommended by previous Air Force Scientific Advisory Board (SAB) and Defense Science Board information technology and architecture recommendations, commit to developing new use-driven mission concepts of operations.
- Apply the spiral acquisition process to provide disciplined development and integration into the Air Force.

Managing Combat Information

The BI is a combat information management system based on the study team’s 11 findings:

1. Combat information requires management
2. A staff function is required to manage information
3. Information validity is achieved through authenticating inputs and tracking information pedigree
4. Selected information needs constant updating
5. Data must be organized by referencing and cataloging
6. Data must be assembled into useful information

7. Information must be presented at the user's desired level of knowledge
8. Subscription or search finds the right information to meet user needs
9. Objects can be published for common sharing
10. The BI creates a common operating picture (COP)
11. Human control, with rule-based information decisions, is required to achieve rapid and accurate decision cycles that provide information superiority

Study Assumptions

Managing information must span the spectrum from peace through war. This study focused on the management of combat information for the warrior with emphasis on the move from information "pull" to "use-driven" concepts. Bandwidth, connectivity, computation, storage, assurance, and protection are outside the scope of this study. Future combat information management systems must incorporate all appropriate information (noncombat, open-source, etc.) and must also accommodate joint and/or coalition missions.

The Vision of Information Has Been Evolving

The BI is the next step in the evolution from system-centric through network-centric to information-centric. Network-centric warfare is a first step in the direction of forming a common view of the battlespace by ensuring ubiquitous connectivity. Network-centric systems gain their operational advantage by integrating existing planning and warfighting systems via a communications network. The BI extends the concept of the network-centric system. It remains essential that existing and evolving function-specific systems be interconnected and able to intercommunicate. But in the BI, capabilities for intelligent data transformation, information exchange, knowledge sharing, and processing provide the operational advantage.

CINC/CJTF Control of the Battlespace InfoSphere

The BI enables the Commander-in-Chief (CINC) or a Joint Task Force Commander (CJTF) to define operational policies, concepts, and access while organizing information support around current operations. The operational commander creates a BI for a specific purpose. Some BIs will remain in constant operation to support potential conflicts, Korea for example. Other BIs, for example a noncombatant emergency operation, are created for a limited time. Exercises would build BIs to manage the simulated combat information in their scenarios.

Describing the Battlespace Infosphere

The BI provides a highly tailored repository of, or access to, information that is designed to support a particular geographic area or mission. The intent of the BI is to have a "single place," a "virtual system of information systems," that serves as a clearinghouse and a workspace for anyone contributing to the accomplishment of the operation—for example, weather, intelligence, logistics, or personnel. The use of the BI seamlessly integrates multiple sources of data, enables automated manipulation of data, provides faster response times, and produces tailored information to support warfighter decision making throughout all functional staff activities.

The Battlespace InfoSphere Combat Information System

The BI integrates five essential elements of military operations: command, planning, execution, combat support, and information support. At present, the command, planning, and execution functions are integrated in the Theater Battle Management Core System (TBMCS). However, the TBMCS does not integrate combat support and has no capability to manage combat information. It is a very closed system.

The BI will serve as an integrating system in that each function will interact with or be part of the BI while maintaining its own unique required actions. The level of integration with the BI will depend on the information needs of the function and how those needs can best be met. Figure E-1 shows the dependent and independent relationships between these existing systems and the BI.

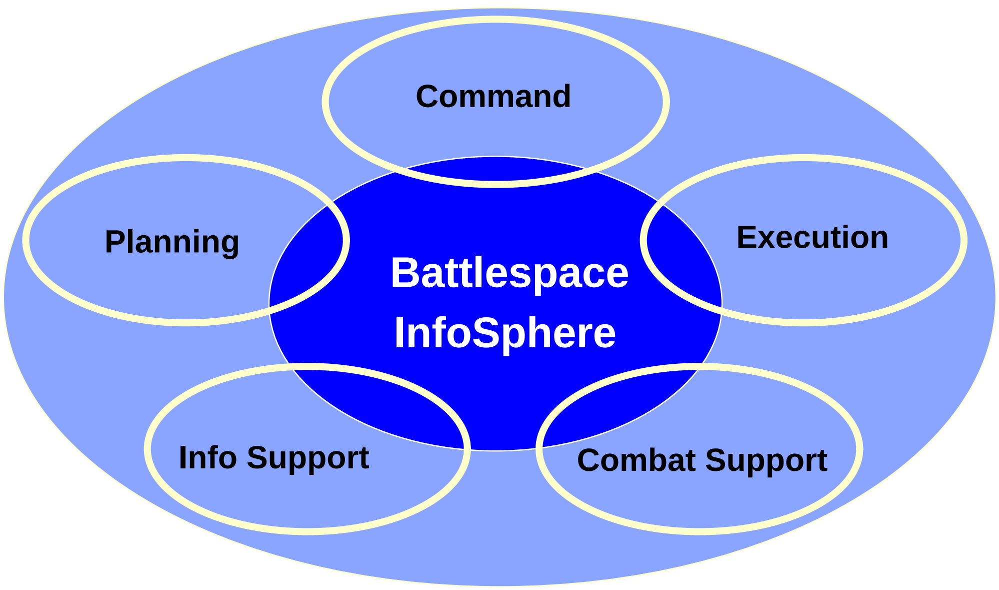

Figure E.1. *Integrating Present Information Systems*

An Operational Example of the Interrelationship of Combat Information Systems

An operational vignette may help to illustrate how existing and planned information systems interrelate with the BI. The scenario begins when an attack on a suspected enemy SAM site is planned. Using planning tools in the TBMCS, the planner selects the approximate coordinates of the suspected site and dips an “information cup” into the BI to pull out the information geospatially referenced to that location. The planner views the cup that includes current imagery and determines that the target is a SA-10 site. The planner adds SA-10 data to the cup and posts the cup of information to the BI as a proposed target. Outdated or unnecessary information is automatically stripped out of the cup.

The A-3 operations officer subscribes to proposed targets in the BI and therefore instantaneously receives the proposed target and its cup of information. The operations officer reviews, approves, and prioritizes the target and posts it in the BI as an approved target.

The execution manager subscribes to approved targets in the BI and instantaneously receives the approved target and its cup of information. Based on location and priority, the execution manager assigns the target to an airborne F-16. The target assignment is posted in the BI.

The F-16 subscribes to target assignments in the BI and, therefore, instantaneously receives the target. However, the cup of information about the target is automatically reformatted to contain the information that the pilot is capable of viewing in the F-16 cockpit. The pilot then attacks the target using the information gathered by the planner and updated by the execution manager.

This scenario depicts the interaction of the BI with existing systems. The information on the target was assembled or aggregated only once, although the status of the target changed several times. The publish-subscribe concept that implicitly moves information from creators to users is described in detail in Chapter 3.

The information in the cup needs to be current at all times in the process to ensure that the F-16 can kill the target. The cup subscribes to the sources of information that filled the cup when it was created. This subscription ensures that each warrior who uses the cup is constantly updated. Other operational vignettes are included in Chapter 4 to further illustrate the BI in operation.

The Component Functions of the Battlespace InfoSphere

Functions within the BI fall within three broad categories: input, manipulation, and interaction. Information must get into the BI, information must be manipulated to produce knowledge, and people or functions must be able to interact with the knowledge-rich results of the manipulation. These functions, shown in Figure E-2, are discussed in more detail in the following paragraphs.

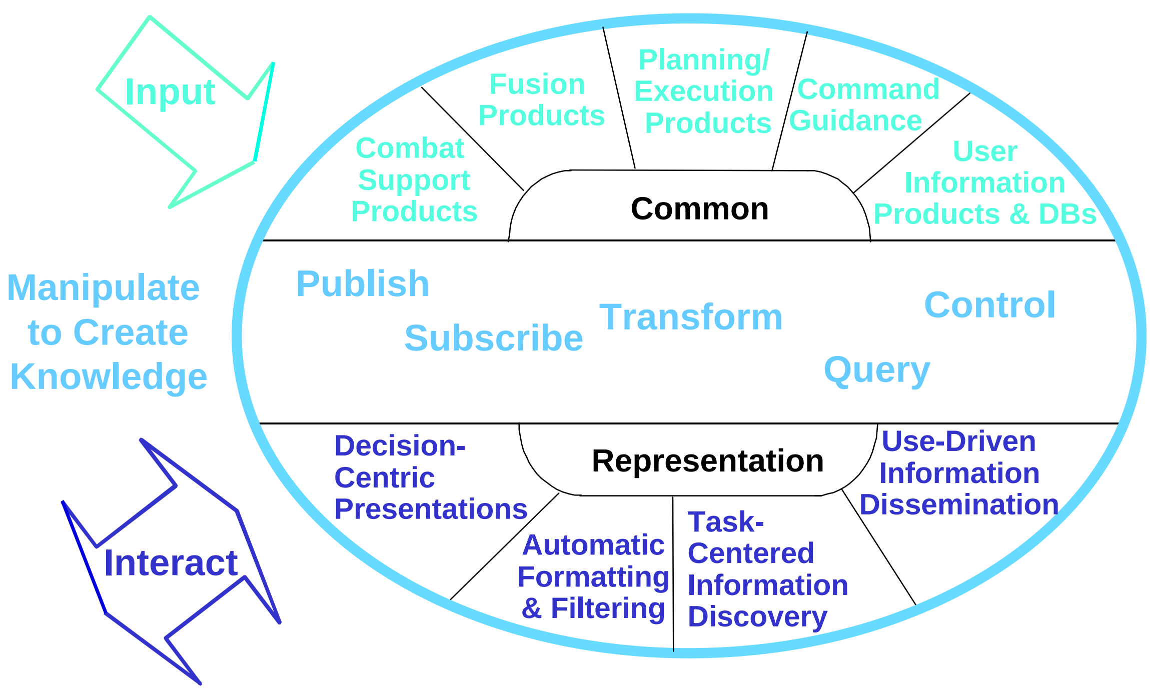

Figure E-2. *Components of the Battlespace InfoSphere*

Elements of the BI are objects that encapsulate knowledge about the battlespace and that are created and exist within the information realm. During an object's lifetime there are three main types of actions that can be performed: *input, manipulate,* and *interact*. Objects are *input* into the BI from various sources and made available for manipulation within the BI. Objects are *manipulated* in the BI by five actions—publish, subscribe, transform, query, and control. Once in the BI, objects can also *interact* with entities outside the BI, such as people, legacy systems, and external databases.

Basic Concepts of the Battlespace InfoSphere

The core features of the BI are based on the concept of manipulation to create knowledge. This concept is composed of the ideas of publishing objects in the BI so that they can be shared with others; subscribing to objects to be instantly provided with the most up-to-date information; transforming objects into new objects, representations, or aggregate objects to create higher levels of knowledge; allowing queries to find information within the BI; and controlling the operation of the BI to ensure that it is correct and robust.

Sharing of Information via Publish and Subscribe

The "publish and subscribe" mechanisms are the key to the BI. They provide the means for communication among systems and people, and a record of published information that can be queried or analyzed. But unlike book or newspaper publishing, BI publish-subscribe transactions can operate quickly to form sensor-to-shooter connections and other real-time linkages. The publish-subscribe mechanism suffices to provide the wide range of communication and system-integration functions needed by the BI. To amplify the design of the BI, the panel discusses four important aspects of the design: (1) information objects obey standard definitions; (2) use-driven object routing and sharing via publish/subscribe; (3) transformation and aggregation via fuselet processing; (4) control of BI functions; (5) Battlespace InfoSphere services; and (6) a common operating picture.

1. Information Objects Obey Standard Definitions

The BI stores objects that record battlespace information. These objects might be likened to electronic forms rigidly structured to record, in separate named fields, all the information required to describe the object.

2. Use-Driven Object Routing and Sharing Via Publish/Subscribe

The most powerful mechanism within the BI technical architecture is the concept of "publish and subscribe." When a new object is created as a result of acquiring new information or interacting with warfighters, using the processes illustrated in Figure E-3, the object is "published" on the BI. Publishing makes the object instantly available to people and processes that access the BI. BI participants will usually "subscribe" to such objects by specifying the essential properties of objects they seek. Thus the publish-subscribe mechanism forms communications links between the providers and the seekers of information.

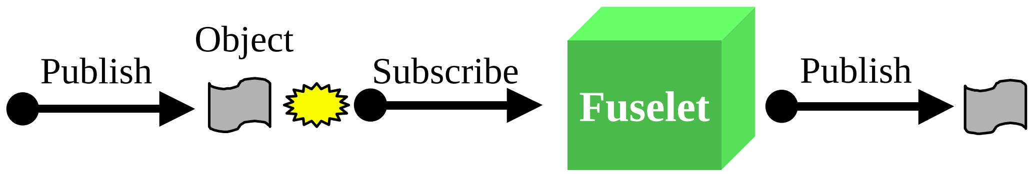

Figure E-3. *Information Flows Using Publish, Subscribe, and Fuselet Processing*

3. Transformation and Aggregation Via Fuselet Processing

While the publish-subscribe mechanism routes objects from sources to seekers, it is the collection of BI processes that actually perform information-processing activities such as fusion, aggregation, and filtering. The panel has chosen to name these subscription-driven processes fuselets, recognizing that a common application of such processes is to fuse information from several sources into knowledge. The fuselet enters one or more subscriptions to collect the information it needs. Whenever a new object is published that matches a subscription, the fuselet is triggered and executed. The fuselet may examine the newly matching object and determine that it is not relevant to the fusion task for which the fuselet is responsible; subscriptions provide a coarse filter on objects, but only the subscriber can examine the details of the object fields and make decisions. If, on the other hand, the fuselet determines that it should issue new results, it publishes a new object to the BI, which in turn may trigger other fuselets.

Fuselets have many uses: they can bring information into the BI, transform sets of BI objects into aggregated objects, or gather objects for presentation and automatic report generation. The inputs to fuselets typically are subscriptions to BI objects, and the outputs, where needed, are typically in the form of the publication of further objects.

4. Control of BI Functions

The BI must maintain at all times a real-time, situation-aware, dynamic picture of the battlespace. A set of management and control functions is required to keep the BI operating smoothly and correctly. These tools monitor and control such aspects as performance, bandwidth allocation, security, data management, configuration, and repair.

5. Battlespace InfoSphere Services

The BI contains a set of standard processes necessary for creating and controlling a mission-specific BI, as well as for publishing and subscribing to BI objects. Some of these services are intended for direct use by computer programs (for example, publish-subscribe services), while others are provided by tools operated by people with the responsibility for managing the BI. These services include:

- Object definition services
- Publish-subscribe and query services
- Establishment services, used to create and configure a new BI
- Access control services
- Data and bandwidth management services

- Performance monitoring and information process control services
- Coordination services

6. A Common Operating Picture

The consequence of the BI is that every user will be using current information constantly updated without the necessity of searching. Data will be aggregated into usable knowledge to share with others who have similar requirements, thus reducing the frequency of aggregation, with corresponding reductions in bandwidth and processing power demands.

Key Enabling Technologies and Programs

The technology requirements imposed by the BI stem from the need to input, manipulate, and interact with information in an efficient, effective, and secure manner. These three goals can be met with nine types of enabling technologies that support the publication, subscription, query, control, transformation, and secure storage of information within the BI. Efficiency is enhanced by intent inferencing, wrapper technology, heterogeneous data integration, information life cycle, and geographical and temporal referencing. Effectiveness is enhanced by domain- and task-specific workflow management and visualization. Security is enhanced by multilevel secure storage.

The limited technology evaluation by the panel resulted in the database shown in Appendix D, which includes 584 records linking ongoing research and development (R&D) programs and 83 specific technologies. This includes 207 programs or projects, with many programs or projects having more than one linkage. The panel evaluated the technologies in several ways: priority for Air Force investment, maturity of technology, and readiness of technology to support the BI. Currently there is an average of seven ongoing R&D programs per technology need; 93 percent of technology needs are covered by two or more programs; and 64 percent of technology needs are covered by five or more programs. It is clear that overlapping programs must be coordinated and, where justified, combined. The major programs in this limited evaluation that best seem to support development of the BI are Command Post of the Future, Dynamic Database, and the Joint Targeting Tool.

The technology assessment leads to a fairly straightforward conclusion: The technologies needed for the BI are, for the most part, being vigorously researched throughout government and industry. There are a few areas that warrant more investment. Nevertheless, the state of the art on which the BI can be based is very rich indeed. To take advantage of this richness, investments in technology transfer and integration will be needed.

Implementing the Battlespace InfoSphere

The panel outlines a development approach and procurement discipline for achieving a BI. The Electronic Systems Command (ESC) spiral development model is proposed as the desired method of incrementally achieving a BI. The panel then proposes a strategy for leveraging existing Air Force and DoD assets using this model. The panel then identifies current R&D efforts that can be used as a springboard for BI development. Finally, the panel proposes a procurement discipline similar to that for other major weapon systems.

The evolution of the BI will involve concept evolution as well as technology evolution. Thus, a spiral approach to the development of the BI will be the most appropriate. Figure E-4 shows that the evolution model starts with a set of mature technologies plus an initial concept. The initial experiments will result in a revised concept and possibly a revised list of technologies. The art in using this spiral approach to concept and system evolution is to find the collection of mature technology that will support a meaningful test of the concept. If this spiral development approach is done correctly, this will simultaneously change the way people think about and deal with information while accelerating the development and maturation of enabling technologies.

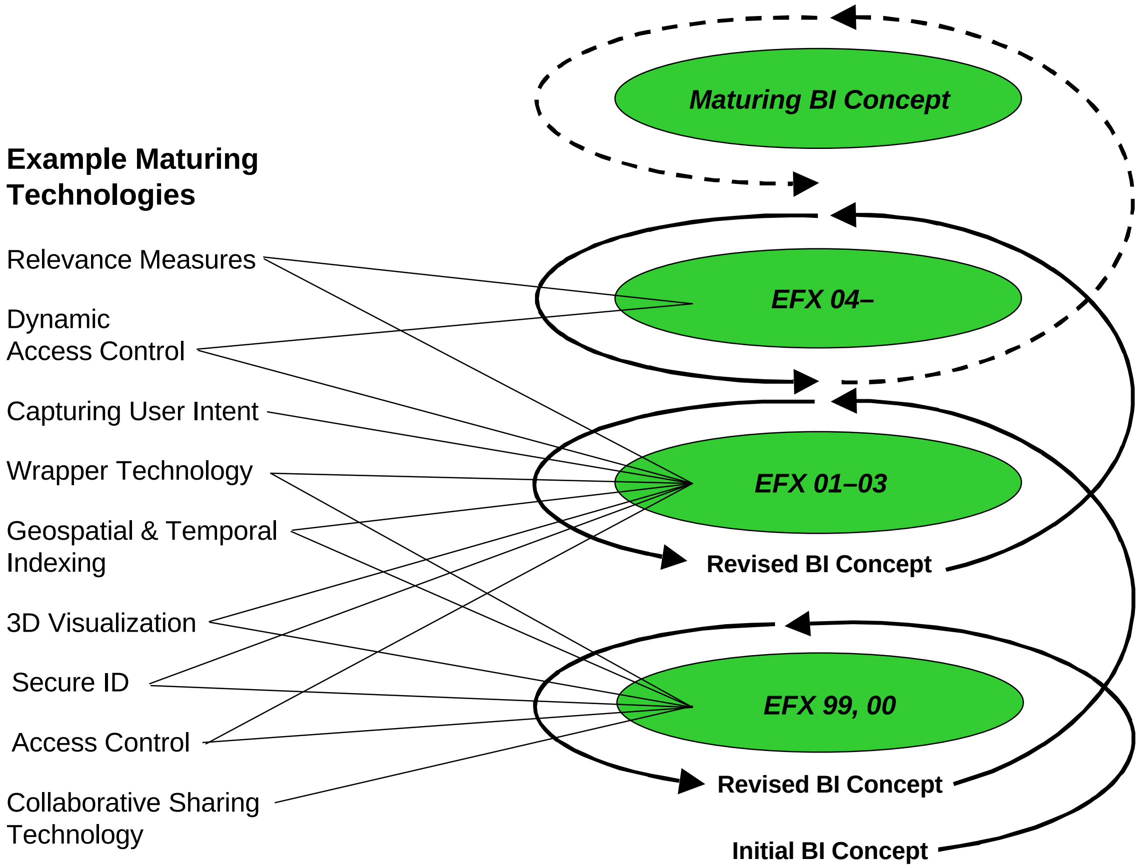

Figure E-4. *Spiral Technology Evolution*

The Road to Battlespace InfoSphere Development

The new Air Operations Center–Rear at Langley AFB, VA, with the supporting Network Operations Control Center is an ideal place to create a BI for development. The ESC and the Command and Control Intelligence, Surveillance and Reconnaissance (C^2ISR) Center assets should jointly develop the capability and bring it into operation in a location where it could be used for operations and training. Other Services would be better able to participate because of the potential for joint development in the Tidewater area. The BI should be considered for a Billy Mitchell Battle Lab Initiative.

The Battlespace InfoSphere Provides the Following Enhancements to the Air Force: It …

- Provides the right information at the right time disseminated and displayed in the right way
- Provides information and knowledge leading to understanding
- Adapts to evolving situation and crisis events
- Provides shared knowledge of current and planned operations
- Enables very high-speed decision cycles
- Consolidates current operational capabilities with integrated decision aids
- Improves data validity through trusted and accountable sources
- Reduces piecemeal system-to-system links
- Reduces duplication of effort in assembling and maintaining information

Study Recommendations

- Approve and adopt the BI as an Air Force vision
- Integrate combat information resources to provide a single integrated structure and a single responsible organization
- Adopt the discipline of a major weapon system program with the speed of spiral development
- Rebalance Air Force information investments to achieve the BI vision as soon as possible
- Seek Air Force leadership but ensure joint development of the BI

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Foreword

This report summarizes the deliberations and conclusions of the 1998 Air Force Scientific Advisory Board (SAB) study on Information Management to Support the Warrior. In this study the panel developed a concept for managing information for all echelons of command. The report identifies a combination of continuing and leveraging the current information management programs and investment, and the concept of a Battlespace InfoSphere.

The study results represent an outstanding collaboration between the scientific and operational communities and between government and industry. The SAB Co-Chairs, Dr. William Ballhaus, Jr., and Mrs. Natalie Crawford, and the Study Chairman, Gen (Ret) James McCarthy, express their thanks and appreciation to the many organizations throughout the Department of Defense that supported this study by hosting the study panel or providing information and presentations. A list of the various meetings held in conjunction with this study is included in Appendix C.

Special thanks go to the panel members who so diligently supported this effort, as listed in Appendix B. The Study Committee would also like to give special recognition to the SAB Secretariat and support staff, in particular Maj Doug Amon; Maj Mark Huson, the Air Force Academy technical writer; and the ANSER support team led by Dr. Robert Finn and technical editor Mr. Stephen Dunham.

Finally, this report reflects the collective judgment of the SAB study panel and hence is not to be viewed as the official position of the United States Air Force.

James P McCarthy

Gen James P. McCarthy

Study Chair, USAF Scientific Advisory Board

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Chapter 1: Managing Combat Information

1.0 Information Support for the Warrior

The Battlespace InfoSphere (BI) is a concept for managing combat information. The complexity of future combat operations and the diversity of operations that the U.S. military must be prepared to conduct require the application of advanced information technology (IT) for the management of combat information available to enable rapid decision making and execution. The study panel concluded that an information management (IM) system, the BI, is required and can be implemented in the near term and enhanced over time.

Chapter 1 of this study report describes the design principles, considers the requirements, and describes the vision and concept of operations (CONOPS) for the BI. Chapter 2 defines the BI and its essential elements of operation. Chapter 3 provides the technical design concepts for the BI. Chapter 4 uses operational vignettes to illustrate how the rule-based technology application can enhance combat operations. Chapter 5 assesses the technology required to implement the BI and prioritizes the investments required by DoD to achieve the vision. Chapter 6 provides research and development approaches and program management concepts to achieve combat IM capability as soon as possible. Chapter 7 offers specific recommendations to implement study recommendations.

Chapter 1 will discuss managing combat information in terms of the following concepts: (1) combat information requires management; (2) a staff function is required to manage information; (3) the BI achieves information validity through control of inputs; (4) the BI provides constant updating of selected information; (5) organize data by referencing and cataloging (6) assemble data into useful information; (7) information is presented at the user’s desired level of knowledge; (8) user needs are met by subscription or search; (9) publish data for common sharing; (10) the BI creates a common operating picture; (11) human control with rule-based information decisions.

1.1 Managing Combat Information

The BI is a combat IM system; its design is based on the study team’s 11 conclusions, listed below:

1.1.1 Combat Information Requires Management

The complexity of future combat operations and the diversity of operations that the U.S. military must be prepared to conduct require the application of advanced IT for the management of the information available to enable rapid decision making and execution. Information dominance requires that most warriors have robust information support to enable them to conduct the operational concepts outlined in *Joint Vision 2010* (*JV2010*). While the warfighter should be able to use search techniques to find information not available in a managed system, most information requirements can be anticipated and refined by training and exercise. Combat operations do not permit the time or diversion from primary functions to search for or assemble information. The panel’s conclusion is that a system for managing combat information is required.

1.1.2 A Staff Function Is Required to Manage Information

Combat IM in the BI must be assigned to a staff organization to create, operate, and sustain the BI. The diverse skills required suggest assembling a staff with operations, intelligence, communications, and logistics experience. Over time, IM will become a functional skill area.

1.1.3 The BI Achieves Information Validity Through Control of Inputs

The BI also permits the control of inputs from authorized and validated sources. For example, the direct feed from the Joint Surveillance, Target, and Attack Radar System (JointSTARS) sensor can be input or altered only by the JointSTARS platform. This becomes an essential element of the overall system assurance efforts.

The valid source information is included as part of the “pedigree” tag. Pedigree information, as its name implies, indicates the parentage of information. It not only helps with validity checks, it also helps conflict resolution among conflicting data. For example, an inexperienced but eyewitness observer may contribute information that is later refined by an onsite expert. Consider that a foot soldier may observe a bridge to be “intact.” An Army Corps of Engineers assessment, however, may declare the bridge unsafe. Pedigree information refines the validity information.

1.1.4 The BI Provides Constant Updating of Selected Information

Once the objects are defined, the BI must provide for selected information to be constantly updated. Publishing change data in the BI ensures that those who have subscribed to that object are continuously updated, thus sharing current data. An example is given in paragraph 2.2.4.

1.1.5 Organize Data by Referencing and Cataloging

Information or data can best be managed by relating it in some way to other relevant information. It can be organized by referencing and cataloging. It can be referenced by geospatial and temporal relationships or event, activity, or organizational relationships. While more complex to use, enemy intent information could be organized by relating the understood elements in an artificially organized reference system that would require user training. Cataloging the information within the database can accelerate access to other databases. Many of these concepts are already being applied to speed Internet access today.

1.1.6 Assemble Data Into Useful Information

Combat operations require knowledge rather than data, and the assembly or aggregation of data to create knowledge takes time, processing capability, and bandwidth as each user seeks to carry out functional responsibilities or make command decisions. The BI permits the creation of knowledge within the system and access to the knowledge by those who need it. This reduces the number of times the aggregation process must be executed by users with similar information needs. Moving knowledge or assembled data as objects within the system is a key to more rapid decision cycles.

1.1.7 Information Is Presented at the User’s Desired Level of Knowledge

Although sharing common information through the BI, each user may individually select the method of viewing the information. Users may determine the level of aggregation at which information will be presented by subscribing to the object that provides the information at the

desired level. In addition, the user may format the information on the desktop or via another presentation method as desired.

1.1.8 User Needs Are Met by Subscription or Search

Users subscribe to information they need to carry out their functional responsibilities or decision making. As information or data are posted to the BI, they are instantly shared with all subscribers. Users may subscribe to thousands of objects and prioritize the subscriptions based on their functional needs. Higher echelons may subscribe for subordinate units or individuals based on their judgment that the information is essential for the organization's needs. Users may search for information to meet their needs with browser technology, but the requirement to search will be significantly reduced.

1.1.9 Publish Data for Common Sharing

Knowledge is shared by a method called "publish and subscribe." Objects are posted in the BI much as objects are posted on a white board or on an Internet page. Objects may be single pieces of data or larger elements such as imagery or a visual depiction of the battlespace. For example, when an intelligence analyst makes an assessment that a surface-to-air missile (SAM) is at a specific location, that assessment becomes an object posted in the BI, probably referenced geospatially and temporally, but possibly by activity or organization. Publishing to the BI permits sharing for all authorized users.

1.1.10 The BI Creates a Common Operating Picture

The concept of "publish and subscribe" enables all users to operate from shared information that eliminates confusion generated in a search. Users search for information using different techniques and at different times. The BI ensures that all users operate from a common information base. An example to illustrate this capability is a COP created by combining inputs from different sources and sensors but published as a single object in the BI. However, the BI concept has a larger context than a common picture of the battlespace in that all information needed to support the entire activity is shared in a common representation.

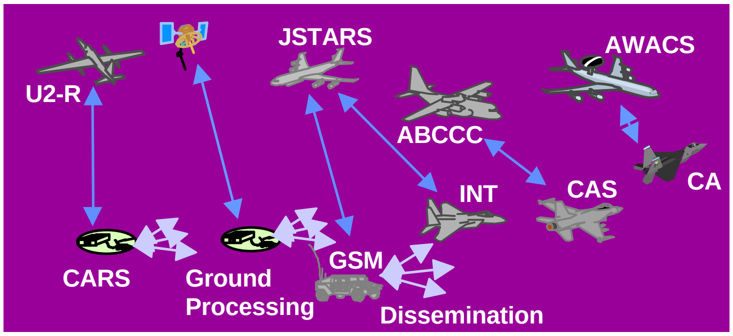
1.1.11 Human Control With Rule-Based Information Decisions

The BI must be based on human control and intervention principles, but many of the processes must involve rule-based automated decision sets to speed the decision cycle. Commanders will have the flexibility to configure the BI to meet operational needs and to determine which rules will govern the automated processes. Some decision processes will be totally rule-based, others will be primarily rule-based but monitored by individuals who can execute or override the rule-based solution, and others will require a person to make a decision. Illustrations of these concepts are found in Chapter 4.

1.2 Today's Combat Information Reality

Today's IM systems are a labor-intensive collection of individual systems that are difficult to integrate (see Figure 1-1). They consist of stovepiped systems that are hard to use in building a recognized operational picture. They are inflexible, are not time responsive, and lead to an

uneven workflow. There is very little interoperability among the Services for joint operations, and even less with U.S. allies for coalition operations.



- Little interoperability
  - Joint-Service
  - Coalition
- Large forward footprint

- Labor-intensive collection and coordination
- Individual stovepipe systems
- Difficult to integrate
- Difficult to build recognized operational picture
- Inflexible
- Time-intensive
- Disjointed workflow

- Scattered snapshots of the battlespace
  - different time
  - different views/aspect angles
  - different parameter names
- Fraction of the information sources used
  - intelligence
  - open sources

Data overload and information starvation

Figure 1-1. *Today's Combat Information Reality*

Today's systems give scattered, inconsistent snapshots of the battlespace, with different times, views or aspect angles, and parameter names. Today only a fraction of the information gathered (from either intelligence or open sources) is used. The result is significant data overload and—at the same time—information starvation, because users cannot find what they need in the morass of available data.

1.2.1 Legacy Systems

Today's combat systems are a result of the Air Force's historical acquisition process. The Air Force organizes around individual system programs, their requirements, their concepts of operation, and their employment. The result is labor-intensive collection and coordination of information encapsulated in these stovepiped systems. These individual stovepiped systems are difficult to integrate across, and it is difficult to integrate their information products; as a result, it is difficult to develop a COP. The systems do not have the basic agreements on what various data elements actually mean. The system of individual systems is brittle, inflexible, and time-intensive, and creates disjointed work and process flow. This system of individual systems is difficult to integrate within a Service and impossible to integrate across Services. The result is little interoperability in both the joint and coalition environments. When employed forward operationally, multiple, independent support systems must be deployed and supported.

1.2.2 Operational Impact

The major consequence is that the commander and the warfighters lack a common understanding of the battlespace. The individual stovepiped systems sample operations at different points and

in different times. The result is a confusion of different views and aspects of the battlespace without commonly understood parameters and names. An additional impact is the inability to take advantage of intelligence and open sources of information because of differing classifications and network connections. The implication for decision making is an overload of poorly organized and incomplete data and little usable information, meaning that cognitive effort that should be focused on the operation is being used to overcome artifacts in the data presentation. The migration toward network-centric warfare will resolve many of the problems created by the weapon-centric approach. Integrating the access and flow of data provides significantly more combat capability than any collection of individual systems. The evolution toward network-centric warfare provides for enhanced access to data but does not resolve the need to integrate data and information. The inability to integrate information or view the operational problem from an information perspective requires the next evolutionary step toward a BI.

1.3 Current Approaches to Resolving These Limitations

The Air Force and DoD have attempted to resolve these problems by a variety of initiatives, all required as necessary steps along the way to a more robust IM approach. DoD has created a Defense Information Infrastructure in an attempt to provide a common backbone to integrate systems. It has established technical standards for interoperability and created architectures for some operational systems. The Global Command and Control System (GCCS) and the Global Command Support System are efforts to provide warfighters with combat and support information.

Combat systems are moving toward internal Internet-type solutions using web-based technology, including search engines. While these are important advances, they are insufficient to meet the requirements of the warfighter.

1.4 The Requirement and the Challenge of Information Management for the Warrior

Commanders, warfighters, and other combatants require an integrated, global awareness and mission understanding that enable real-time planning, control, and execution of the aerospace mission with a minimum number of people and equipment forward deployed to the area of operations. The specific need is for a BI that can be tailored in size and geographical representation to meet the operational, maintenance, logistics, and other warfighting requirements of unified, subunified, combined, joint, and/or coalition operators. The BI must provide the mechanism for integrated mission understanding, shared awareness, shared planning, shared execution, shared visualization, shared support, and shared future view. The requirement and the challenge are for

- The *right* information at the *right* time
- Disseminated and displayed in the *right* way
- So that commanders (and "crew warfighters") can do the *right* things at the *right* time in the *right* way

The objective: do it all faster than the other guy, thereby ensuring *information superiority*.

1.4.1 The Emerging Importance of Information Superiority

Information superiority is the bedrock on which the goal of *JV2010* "full spectrum dominance" rests. Today information is gathered from a number of independent assets; very few of them are

integrated for a coherent view of the battlespace. These stovepiped systems are rapidly being left behind as the need for a BI containing distributed, collaborative, real-time and near–real time processing, distribution, and decision-making capabilities becomes apparent. The lack of integration among the current IM systems requires unique interfaces that entail large and costly operations. To gain information superiority, the United States must develop and test automatic systems and processes that integrate (fuse) information from independent assets to satisfy requirements, along with global, trusted, robust, high bandwidth connectivity for assured battlespace command and control (C^2).

The policy of centralized management and decentralized execution supported by a BI architecture enables complex distributed operations. Information superiority provides a basis for distributing decision making while maintaining central coherence across the force. Commanders and warfighters responsible for executing specific parts of the plan will have increased authority and information to make decisions, manage resources, and execute plans associated with their tasks. This will include increased delegation of authority over intelligence, surveillance, and reconnaissance (ISR) assets and over maneuver, strike, and protection assets. Initiative to make decisions and to execute will be delegated so that forces are self-synchronizing and used to maximum effectiveness. Information access and the tools of command must be appropriate to a unit's combat power, independent of command echelon.

1.5 The Solution to the Information Management Challenge

The solution is to:

- Continue the evolution begun by the initiative of network-centric warfare and leverage and explore the current IM programs or investments and new Joint Operational Concepts for their compatibility with network-centric warfare.
- Build a BI for managing information. Based on previous Air Force Scientific Advisory Board (SAB) and Defense Science Board (DSB) information technology and architecture recommendations, commit to developing new mission concepts of operations that are use driven.
- Apply the evolving acquisition concepts that provide disciplined development and integration into the forces, and use rapid spiral development that will be responsive and useful to the users' needs.

These recommendations are amplified below.

1.5.1 Continue the Evolution to Network-Centric Warfare

Throughout history, technological innovation has profoundly affected military concepts and doctrine, offering significant advantage to the nation that recognized and leveraged the opportunities created by innovation. The current revolution in military affairs, which has accelerated since the end of the Cold War, is being driven by important changes—particularly the emergence of IT as a commercial and social force. Knowledge-based systems are evolving at a rapid rate, affecting all forms of competition and national security. To keep up with this rapid innovation and ensure that U.S. forces have technological capabilities that match or exceed those of the enemy, new products (both commercial and military), services, and technologies must be inserted properly to evolve from the patchwork command, control, communications, computers, and intelligence (C^4I) systems of today.

1.5.2 Leverage and Explore Current Programs and Investments

The current vision of information superiority builds on the concept of network-centric warfare and the “system of systems” architectures. The vision is that the integrated sum is far more capable than the set of individual systems. Just as a system-of-systems network can be developed, a system-of-systems networked information program must be developed. The Office of the Secretary of Defense, the Services, and the Commanders-in-Chief (CINCs) are sponsoring 48 Advanced Concept Technology Demonstrations (ACTDs). Thirty-one of these ACTDs are dominated by information superiority. Likewise, the Services’ Advanced Warfighting Experiments draw heavily on information. The Air Force cannot ignore the information revolution occurring around it in industry. The challenge will be to integrate not only the systems but also the very process by which programs are integrated in a “program of programs” approach (see Figure 2-1).

1.5.3 Leverage New Joint Coalition Operational Concepts

The United States has an opportunity to capitalize on its expertise in developing and applying IT by leading the global shift to a new type of information-based warfare that emphasizes delivery of comprehensive knowledge to warfighters at the tactical level. This differs from current practices that focus mainly on providing data and focus information support at the strategic and national levels. The BI uses IT to provide warfighters with the knowledge that will permit them to employ forces and mass effects in revolutionary new ways to ensure U.S. military supremacy into the 21st century. The information-centric rather than network-centric integration of operations will enable new joint/coalition operational concepts not possible today. For this reason the development of the system and the development of operational concepts must be joined in a continuously evolving spiral as discussed in Chapter 6.

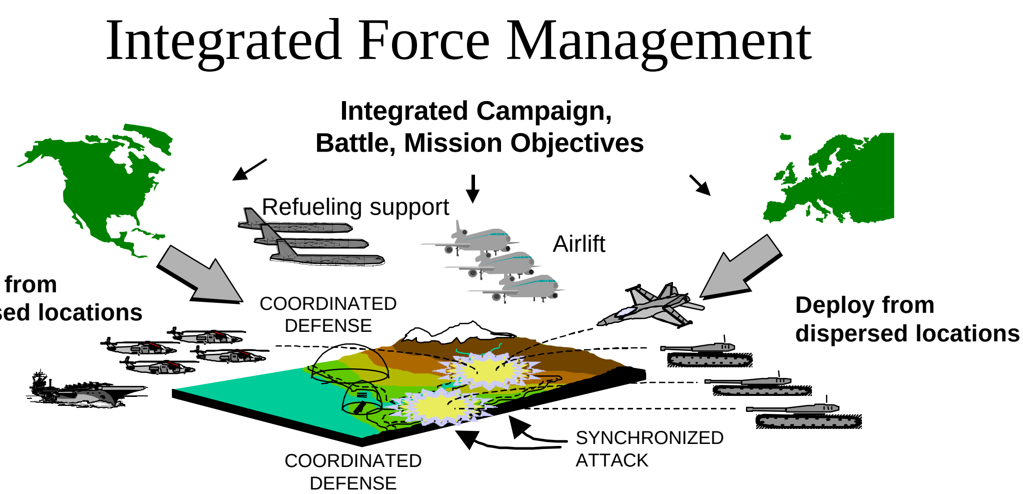


Figure 1-2. *Integrated Force Management*

1.5.4 Build on Air Force SAB and DSB Recommendations

Both the Air Force SAB and the DSB have been recommending that information superiority be vigorously pursued and that geospatial-temporal models be used to organize information and

data. Information that is used to produce both new information and knowledge that leads to actions must be organized around the sources and destinations of information and indexed appropriately.

1.5.5 New Mission CONOPS to Be Use-Driven

The new information-organizing principle is to present use-driven information (or knowledge) to the warfighter. This is information demanded at the time in the conduct of the mission. *Push* and *pull* concepts of IM would be replaced by use-driven IM. Then push and pull information would automatically occur as the mission progressed, providing all the right information to the commander and warfighter at the right time.

1.6 Future Combat Operations Require a Battlespace InfoSphere

A stressing point for IM will continue to be combat operations, especially as the United States and its potential enemies develop newer computer-driven weapon systems capabilities. This will result in an ever-increasing appetite for greater accuracy and higher resolution of geospatial temporal information, as well as the desire for immediate access to this information from a vast spectrum of users. A client-server architecture based on the principles of the BI will provide distributed information that can be tailored to any required information products, delivered in real or near-real time. Theater or local (as in the case of a small deployed Aerospace Expeditionary Force) control of the BI will greatly help the commander and warfighters synchronize forces and better tailor the excess of information now being produced at the information anchor desks.

To successfully prosecute future combat operations, the United States must have the capability to conduct continuous global information and intelligence gathering, and to conduct those operations in such a manner that warfighters have access to the right information at the right time. It is imperative that mission-relevant information be provided to warfighters as they demand it. Those who must meet that demand need to consider:

- Identifying significant threats, which can appear anywhere in the world or in space at any time
- Countering opposing weapons of mass destruction, theater ballistic missiles (TBMs), and cruise missiles (CMs)
- Using the Global Grid, digital battlefield, demand-improved geospatial-temporal accuracy
- Providing accurate location and target information
- Coordinating target time/space as mandatory for strikes
- Providing force protection and minimizing causalities
- Dominating opposing operations: air, space, land, and sea
- Countering opposing integrated air defense systems and other defenses
- Dominating the information environment and degrading opposing information systems
- Operating in joint and coalition environments, complementing allies
- Supporting contingency operations, which demand a faster, more capable approach

Future combat operations require a BI that can be tailored to present all needed information to conduct warfighting. The BI contains rule-based automatic decision aids, permits pre-programmed

data to flow forward, pushes relevant real-time information to the right asset, and provides friendly presentation or visualization of information. The BI consolidates and integrates the supporting elements of GCCS, TBMCS, COP, MC^2 centers, and the Joint Force Air Component Commander (JFACC) systems, legacy and future. The BI exists for a specific, or potentially specific, warfighting situation.

1.7 Study Assumptions

Information management must transcend the spectrum from peace through war. This study focused on the management of combat information for the warrior. Noncombat information must be integrated into combat information systems. The study assumed four fundamental tenets:

1.7.1 Joint and/or Coalition Missions Must Be Supported

The study assumed that the majority of future combat operations will be joint and with coalition partners. The need to project joint solutions, perhaps led by the Air Force, is critical to continuing the *JV2010* concept. The challenge of providing information system solutions that allow coalition partners to connect, use information, and participate in truly integrated operations, while at the same time protecting information and systems, will be a major consideration in developing the BI.

1.7.2 Move From Information Pull to Use-Driven Concepts

The evolution to information access in the Internet is moving from World Wide Web pull concepts to sophisticated use-driven concepts. Use-driven concepts hide the complexity of information organization and access from the users and their applications.

1.7.3 Bandwidth, Connectivity, Computation, Storage, Assurance, and Protection Are Outside the Scope of This Study

The Global Grid program and the implementation of network-centric warfare are assumed to provide sufficient networking capacity to enable the evolution to information-centric warfare. The focus on combat IM placed these important elements outside the scope of the study.

1.7.4 Future Combat IM Systems Must Incorporate All Appropriate Information (Noncombat, Open-Source, etc.)

Information outside the combat information system is essential to planning and executing combat operations. In some cases, open sources on the Internet may be the most current and complete sources of essential information. The system needs to be able to access that information while protecting the integrity of combat information.

1.8 Our Vision of Information Has Been Evolving

The BI is the next step in the evolution from system-centric warfare through network-centric to information-centric.

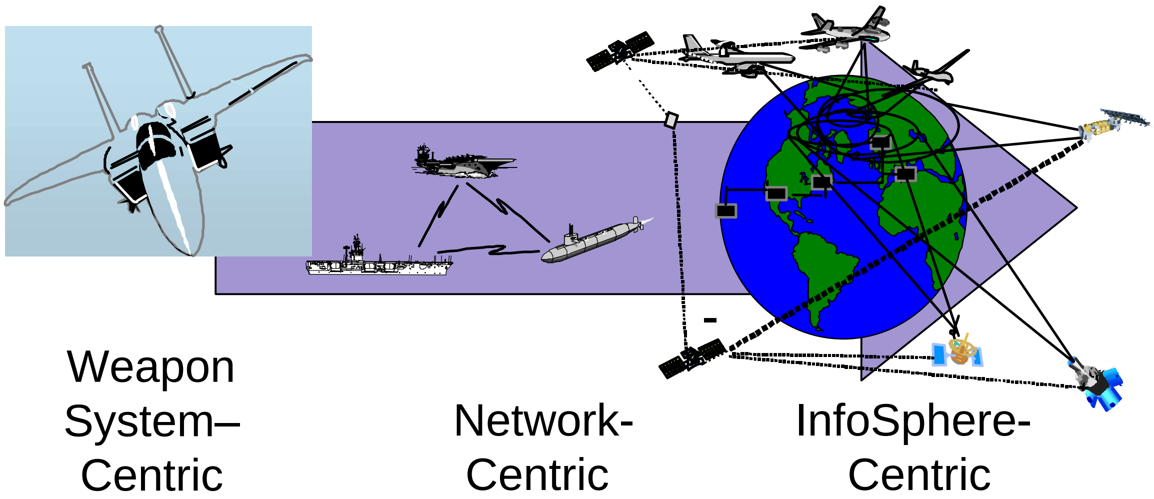


Figure 1-3. *The Vision of Information Has Been Evolving From System-Centric Through Network-Centric to InfoSphere-Centric*

1.8.1 Evolution From Weapon System–Centric Toward Integrating the Battlespace InfoSphere

Desert Storm demonstrated the effectiveness of a system that is weapon system–centric coupled with information sent from independent sensor systems. To improve on these results, an Under Secretary of Defense Deputy Director for Research and Engineering (DDR&E) and the Joint Chiefs of Staff (JCS) J-6 Advanced Battlespace Information System (ABIS) joint task force was formed to improve joint operations through information integration. This study led to the Vision for Future Joint Warfighting described in *JV2010*, which introduced the emerging operational concepts of dominant maneuver, precision engagement, focused logistics, and full-dimensional protection, as well as the enabling capability of information superiority.

One of the challenges in moving toward *JV2010* is that of understanding how information superiority can be exploited to enable the emerging operational concepts to progress beyond systems that are weapon system–centric. An important observation is that the emerging operational concepts can be enabled by operational architectures that closely couple the capabilities of sensors, command and control, and shooters. The primary mechanism for generating increased combat power in 2010 will be “networks” of sensors, command and control, and shooters. Consequently, the emerging operational concepts of *JV2010* can be characterized as moving from Desert Storm’s weapon system–centric operations to network-centric and beyond.

1.8.2 Network-Centric Systems

Network-centricity is a first step in the direction of forming a common view of the battlespace by ensuring ubiquitous connectivity. Network-centric systems gain their operational advantage by integrating existing planning and warfighting systems, interconnecting such systems via a communications network. Such systems are called “function-specific”—that is, specific systems for planning, fusion, execution, and combat support. Improved communications and the ability to coordinate or self-synchronize operations come about through a common network capability for electronic mail messaging, real-time videoconferencing, client-server processing, and transfer

of file data among operational participants independent of location (as long as they are connected to the network with adequate bandwidth).

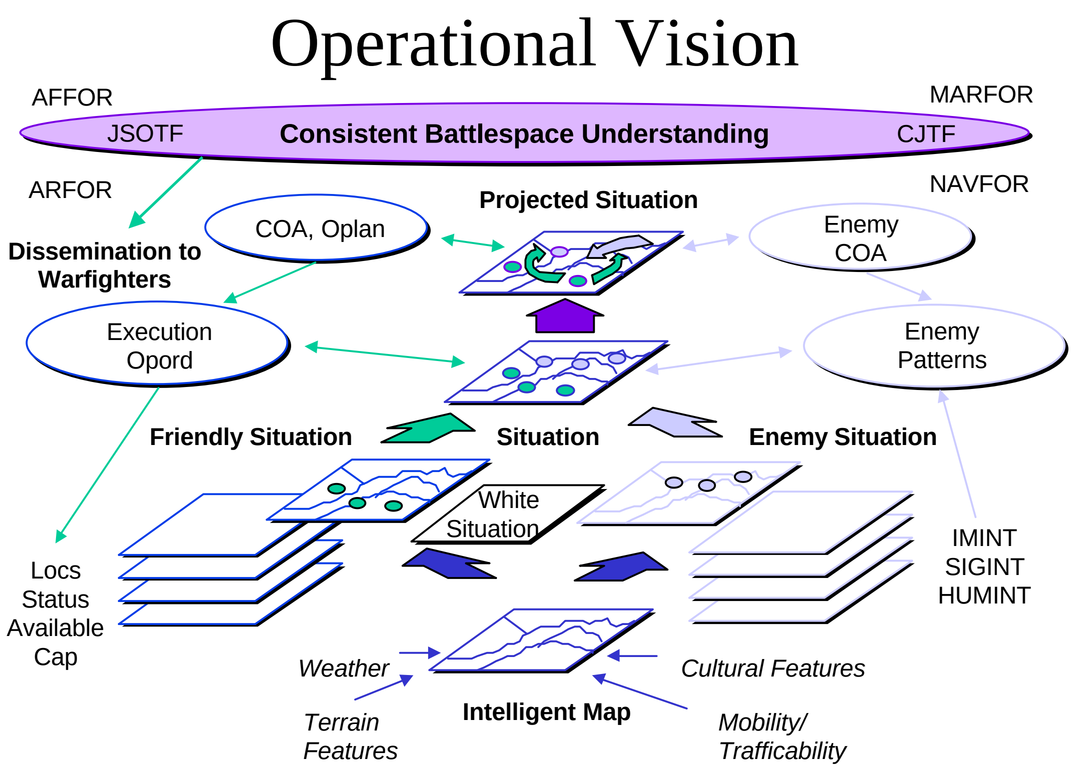


Figure 1-4. *Battlespace Awareness*

Network-centric systems fall short of the ultimate goal of the full-spectrum battlespace awareness and automated decision making that such awareness would enable. “Network-centricity” does not articulate the full spectrum of tools and architectural concepts needed for fully integrating function-specific systems to support a leveraged, crosscutting view of the battlespace. Thus, it is possible to extract only a snapshot of the view of the battlespace as seen by each of the existing functional systems. Integrating these views requires substantial, difficult-to-evolve, ad hoc processing logic. Information flows are hardwired between systems. A dynamic, real-time, ever-evolving picture is difficult to achieve. There is no generalized architectural construct to support the creation of new transformation flows. Also missing is the development of enhanced processing logic (“fuselets”) that builds upon and extends the information products that emerge from the function-specific system. Only with such building blocks will it be possible to achieve automation of the decision processes as well as the creation of a shared view of the battlespace.

1.8.3 Information-Centric Systems ... Beyond Network-Centric Systems

The BI goes above and beyond the concept of the network-centric system, building on and extending it. It remains essential that existing and evolving function-specific systems be interconnected and able to intercommunicate. But in the BI, capabilities for intelligent data transformation, information exchange, knowledge sharing, and processing are central. The

provision of these capabilities is what separates network-centric systems from a true BI. One of the key elements of the BI and an information-centric view is that operations take place on a common shared information base.

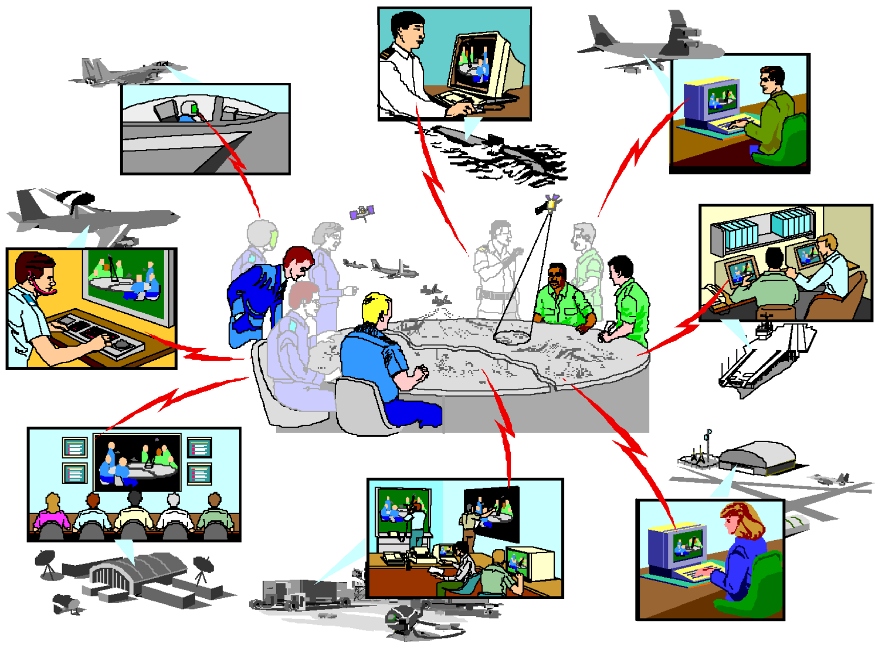


Figure 1-5. *Information-Centric Systems*

1.8.4 The Battlespace InfoSphere of Tomorrow

The BI provides the right information to the right warfighter at the right time. Additionally, it enables the CINCs (and "crew chiefs") to do the right things at the right time in the right way. Going beyond network-centric designs, these information-centric processes introduce the notion of "information object." Although the world is organized around physical objects, people also intuitively understand the concept of information objects. When they want to read a report, they envision the report. The fact that they must remember which file drawer it is stored in is problematic. They envision reading the report, analyze it, and finally generate a new information product (a paper). If the report, the paper, and the process of producing the paper are conducted electronically, then the readers never really needed to know the physical location of the information sources and destinations. The material had, in fact, information space locations. If the system is working correctly, the process of finding the report and publishing the information paper is assisted by automated tools. Likewise the resulting paper is instantly available to others to use in the process of producing new papers. The organizing, retrieval, production, and publication of information occur in the BI, a globally organized and integrated information system designed to carry out the commander's intents.

1.9 Describing the Battlespace InfoSphere

The BI is a logical extension/evolution/next step of today's evolving network-centric IM systems. In simplest terms, the BI may be described as a "virtual system of information

systems" that consists of combining a new software concept with existing and new hardware and software systems to enable a commander (or any authorized user) to use the BI to input, manipulate, and extract information pertinent to the task(s) or mission(s).

The BI provides a highly tailored virtual repository of information, which is designed to support a particular geographic area or mission—for example, a Combined Joint Task Force Commander's (CJTF's) area of responsibility, a CINC's theater, or an activity at the national level, such as a counterterrorism center. The intent of the BI is to have a single place (the "virtual system of information systems") that serves as a clearinghouse and a workspace for anyone contributing to the accomplishment of the commander's mission—for example, operations, weather, intelligence, logistics, or personnel.

Key technical features of the BI include the use of specialized "data objects" and "processing fuselets," which enable the BI to significantly improve the input, manipulation, and extraction of data or information from the BI. The data objects are unique types of data that include "tags" and other reference information that facilitate the rapid sharing of information. "Fuselets" can automatically perform a variety of rule-based or knowledge-based operations on the data or information (for example, routing, fusing, and alerting) that significantly improve the use of IM systems to support warfighters.

The use of the BI integrates multiple sources of data seamlessly, enables automated manipulation of the data, provides faster response times, and produces specially tailored information to support warfighter decision making throughout all functional staff activities.

1.9.1 Managing Information to Implement the Commander's Policies and Intent

There are six attributes that describe the BI: (1) availability, (2) awareness, (3) access, (4) assurance, (5) assimilation, and (6) knowledge and understanding.

1.9.1.1 Availability—Networking the System

- Network architectures—creating global networks from local networks
- Self-healing networks—they must be available and resilient
- Compression—minimizing the size of products without incurring vulnerabilities
- Mass storage—creating ever larger data servers
- High-performance computing—integrated computation within the network
- Fast data finding—accessing and recovering information anywhere
- Translation service—bridging legacy systems and formats
- Bandwidth—growing bandwidth with demand
- Collection management—of all forms, ISR, and open source
- Information synchronization—maintaining currency across the enterprise
- Commercial sources—of technology and information

1.9.1.2 Awareness

- Information organization—on a global basis, accessible to all, everyone aware of its existence
- Filtering—delivering only the correct information
- Privacy issues—protecting the operation and its information

1.9.1.3 Access

- Path management—minimizing load impacts on the network
- Transparency—making the information enterprise transparent to users
- Bandwidth management

1.9.1.4 Assurance

- Information security/signals security/multilevel security—protecting the information
- Defensive info warfare/alarm—protecting the information system
- Data tagging—meta-data tags to allow access and reasoning
- Assured delivery—ensure that information is delivered, without error, and timely
- Source assurance—allowing only validated information sources to publish

1.9.1.5 Assimilation

- Dealing with data glut—minimizing incorrect data and data errors
- Decision and display support—allowing the human to assimilate information
- Visualization—simplifying the human's use of information
- Fusion/correlation of multisource data—automated production of new information products

1.9.1.6 Knowledge and Understanding

- Creating situational assessment—understanding the battlespace
- User driven—keeping the human in the loop
- Simulation—alternative futures, current capabilities, planning assessments, course-of-action assessments
- Common operational picture—keeping everyone on the same sheet of paper

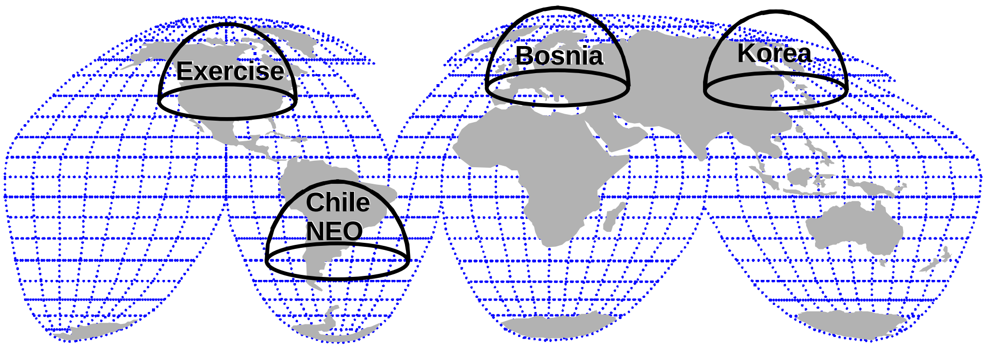
Unlike the Internet, which offers general access to information, the BI needs to be able to tailor information access to operations and the commander's intent.

Creating and deploying the BI will be a challenge. The Air Force will need to develop new concepts of acquisition built on spiral development and heavy user involvement. The Air Force will need to develop techniques to leverage the information industry, create middleware integration tools, and unify architectures.

1.10 CINC/CJTF Control of the Battlespace InfoSphere

The BI allows the CINC or a CJTF to define operational policies, concepts, and access while organizing information support around current operations. The operational commander creates a BI for a specific purpose. Some will remain in constant operation to support potential conflicts—

Korea may be a good example. Others are created for a limited time, like the noncombatant emergency operation for Chile illustrated in Figure 1-6. Exercises would have BIs to manage the combat information in the scenario.



CINC/JTF tailored view of information

Commander defines operational policies, concepts, and access

Organized around operations

Globally interoperable infrastructure and services

Global access—locally organized

Information sharing based on commander's intent

Figure 1-6. *CINC/CJTF Control of the Battlespace InfoSphere*

1.10.1 Organizing Information Operationally

The BI will give the CINC/JTF global access to information but locally organized so that the commander can share information based on the commander's intent. The unique element of the BI is that the commander's intent, policies, and plans tailor the access to and use of information. Information is organized around the operation rather than the operation's being organized around available information.

The CINC and CJTF build the BI on globally interoperable infrastructure and services. This ensures training and interoperability while permitting locally organized information to meet the commander's needs.

1.10.2 Protecting Information

Protecting the operation will require the deployment of operation or security enclaves. An enclave is a control system emplaced on the information systems to implement the commander's policies on access and use of information. An enclave can be implemented using techniques such as the National Security Agency's key agile encryption system FASTLANE, developed under the Global Grid Program. FASTLANE allows thousands of separate enclaves to coexist within one information system and network. Global Grid allows new concepts in networking.

The employment of the enclave concept allows the commander to extend or deny access to individuals, organizations, and systems. The deployment of the BI on a global scale with the use of enclaves will implement trusted reachback. Integrating exercise facilities into the operational enclave permits mission rehearsal of forces before deploying into the theater of operation. It

is this information-centric environment that will allow new methods of planning, command, execution, and support.

1.11 Summary

The study panel concluded that future combat operations require a system for combat IM. The evolution from platform-centric information to the BI is essential and technically possible. The BI is functionally described in Chapter 2.

1.12 Recommendation

Approve and adopt the Battlespace InfoSphere as an Air Force vision. This vision will provide a common goal for integrating disparate systems into an information-rich environment that enhances operational capabilities and combat effectiveness. This activity needs to occur at the Chief of Staff level.

Chapter 2: The Battlespace InfoSphere

2.0 Introduction

The BI will provide a uniform and flexible environment for the conduct of all military operations. However, the first concern should be with the conduct of combat operations rather than support functions. To better understand how the BI would operate in a combat environment, increasing combat effectiveness, this chapter describes the relationship between BI and combat operations in terms of some current supporting information systems.

This chapter first describes the overall structure of the BI from the perspective of the functions it performs. Current information systems are then discussed in relation to the each other and to the BI. Then an operational example of relationships between combat information systems is explored. The chapter concludes with an examination of the functions within the BI and their relationships to each other.

2.1 The Battlespace InfoSphere of Tomorrow

The BI provides the right information to the right warfighter at the right time. Information is the enabler that allows the warfighter, whether CINC or "crew chief," to make the right decisions, leading to doing the right thing, in the right way, at the right time. Technologically, the BI represents an evolution from the systems of today through the network-centric systems envisioned in the near term. As new information technologies evolve, they will be applied to solve the problems of information management addressed by the BI.

The BI will also represent an evolution in the operational use of information. Access to information will be controlled not by the knowledge of where a piece of information is located, but by the authorized need for the information. When pieces of information are viewed as objects, all the relevant characteristics associated with the information can be maintained with it. For example, a piece of information about the location of a Scud transporter-erector-launcher (TEL) will have a source, date and time, and reliability factor (among other things) associated with it. This is a common practice in information management and will allow information to be precisely defined and identified.

Warfighters use the BI to route information flexibly according to their needs and to the needs of other warfighters. An information object may be "pushed," or sent automatically to individuals who have expressed a need for such information. For example, a strike aircraft may ask to be notified of any new threats close to its intended target. This request automatically causes any relevant information entering the BI to be "pushed" to the strike aircraft for its immediate attention. Alternatively, a warfighter may "pull" information from the BI using search techniques, perhaps to find any information that has been recorded in the past 10 days relevant to a particular aircraft. Another way to pull information from the BI is to "browse" for information objects that are not normally routed automatically because it's not possible to anticipate their use in the fight.

New or synthesized information can be made available to others by publishing it in the BI. For example, intelligence analysts may receive raw sensor information objects to which they

subscribe. Their analysis reports, based on these objects, will be made available to others by publishing them in the BI. Once these objects are in the BI, those who are authorized to receive the information and have expressed a need for it will be sent the analysts' reports. The organization, retrieval, production, and publication of information occur in the BI, a globally organized and integrated information system designed to carry out the commander's intent.

2.2 The Battlespace InfoSphere Combat Information System

The BI provides the means for operators and support functions to meet mission requirements in a seamless environment. The functional responsibilities to conduct operations must still be met, regardless of the method used. Whether using runners and parchment scroll or the BI, each person involved needs to receive the right information at the right time. As observed in today's contingency operations, mission functions and information are forced to be distributed to geographically separated units. This distribution of assets complicates the conduct of warfare. The BI combat information system must support all levels of military operations—command, planning, execution, combat support, and information support—anywhere, anytime, from a distributed base of operations.

These levels and their interactions and purposes are discussed further in the following paragraphs. The interrelationship is represented by Figure 2-1. Each function will interact with or be part of the BI while maintaining the unique actions required of it. The level of integration with the BI will depend on the information needs of the user and how those needs can best be met. It will also depend on the information products produced by the function, and the number and disparity of purposes of the users of that information. Figure 2-1 captures some of the dependent and independent relationships between these existing systems and the BI.

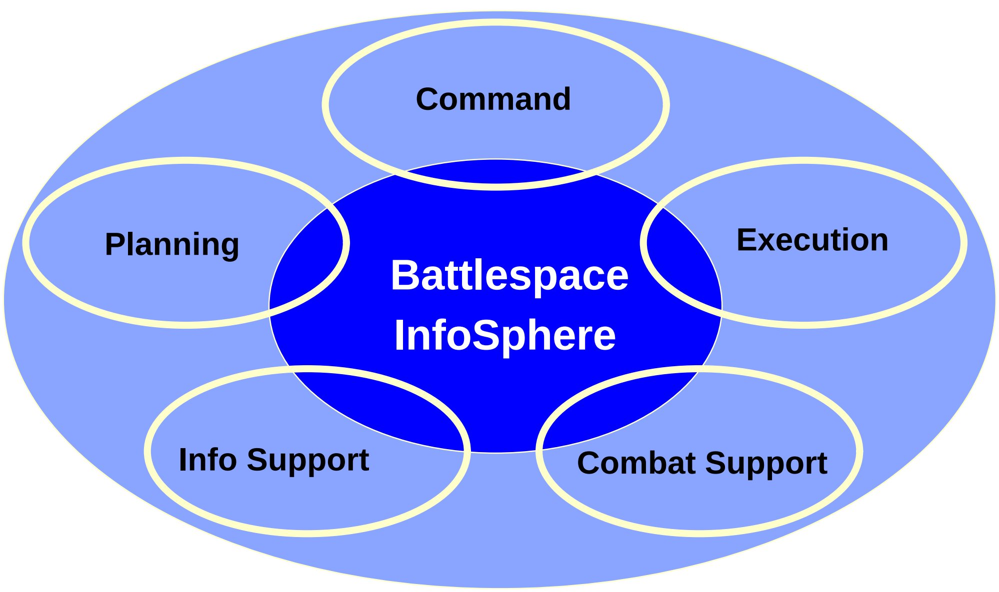


Figure 2-1. *Integrating Present Information Systems*

2.2.1 Relationships of Present Information Systems

Current information systems are stovepiped structures, designed to support single functions. Planning systems, command and control systems, and execution systems are all designed to perform very specific functions using information formatted in ways that are unique to the system. Information is seldom shared directly between them. When information is shared electronically, it usually involves human interaction by way of electronic mail or file transfer. There is a definite time delay between the creation of one information product and its availability to other functions requiring it.

Network-centric warfare provides the electronic connections between systems operating in a combat environment. It provides communication between the stovepiped functions and allows the operators of these systems to share information more rapidly than would otherwise be possible. Interaction between the network-connected components requires human intervention. It does not provide for direct sharing of information or the integration of the existing systems.

Integration of existing systems into the BI will require some form of middleware. For example, wrapper technology will be needed to permit legacy systems to create and access information in the BI. Wrapped legacy systems may not be fully integrated into the BI, but they offer useful services until phased out in favor of replacements.

2.2.2 Combat Support System Integration

The systems integrated into the BI of the future must support a geographically dispersed force. One key element left out of many discussions about information systems is the integration of combat support functions. Logistics, medical, personnel, and other systems must be integrated into any BI to permit the commander and other warfighters to make an accurate assessment of the current condition and factors that may affect their plans. This is necessary to make sure that the right people are there to act on the information and that they have the right tools to do the job. In addition, planning, command, and execution systems should provide feedback into the mission support functions to allow an accurate COP to be developed.

2.2.3 The Need for an Information Support System

Information integration will not occur in a vacuum. Neither will it operate in an environment where all possible decisions about information processing, routing, and maintenance of information objects will be known at BI creation. An information support system is needed to allow maintenance and modification of those BI components (hardware or software) that are either independent of all other functions or common to all. This function would support the day-to-day operation of the BI and facilitate reconfiguration to meet new needs for unique operational missions or coalition requirements, or any other situation where the system being operated on is the BI itself.

2.2.4 An Operational Example of the Interrelationship of Combat Information Systems

An operational vignette will be used to illustrate how existing and planned information systems interrelate with the BI. The scenario begins when an operational planner plans an attack on a suspected enemy SAM site. Using planning tools in the TBMCS, the planner selects the

approximate coordinates of the suspected site and dips an “information cup” into the BI to pull out the information geospatially referenced to that location. The metaphor of dipping a cup into the BI describes the process of accessing and retrieving information from the BI. The planner views the cup that includes current imagery and determines that the target is an SA-10 site. The planner adds SA-10 data to the cup and posts the cup of information to the BI as a proposed target. Outdated or unnecessary information is stripped out of the cup.

The A-3 operations officer subscribes to proposed targets in the BI and therefore instantaneously receives the proposed target and its cup of information. The operations officer reviews, approves, and prioritizes the target and posts it in the BI as an approved target.

The execution manager subscribes to approved targets in the BI and also instantaneously receives the approved target and its cup of information. Based on location and priority, the execution manager decides to assign the target to an airborne F-16. The target assignment is posted in the BI.

The F-16 subscribes to its target assignments in the BI and, therefore, instantaneously receives the target. However, the cup of information about the target is automatically reformatted to contain the information that the pilot is capable of viewing in the F-16 cockpit. The pilot then attacks the target using the information gathered by the planner.

This scenario depicts the interaction of the BI with existing systems. The information on the target was assembled or aggregated only once, although the status of the target changed several times. The publish-subscribe concept is described in detail in Chapter 3. One other concept is also illustrated: the information in the cup needs to be current at all times in the process to ensure correct decisions and to ensure that the F-16 can kill the target. The cup subscribes to the sources of information that filled the cup when it was created. This subscription ensures that each warrior who uses the cup is constantly updated with changes. Other operational vignettes are included in Chapter 4 to further illustrate the BI in operation.

2.3 The Component Functions of the Battlespace InfoSphere

Functions within the BI fall into three broad categories. As shown in Figure 2-2, these are input, manipulation, and interaction.

Information must get *into* the BI, it must be operated on or manipulated while there to produce knowledge, and people or functions must be able to interact with the knowledge-rich results of the manipulation. These functions are discussed in more detail in the following paragraphs.

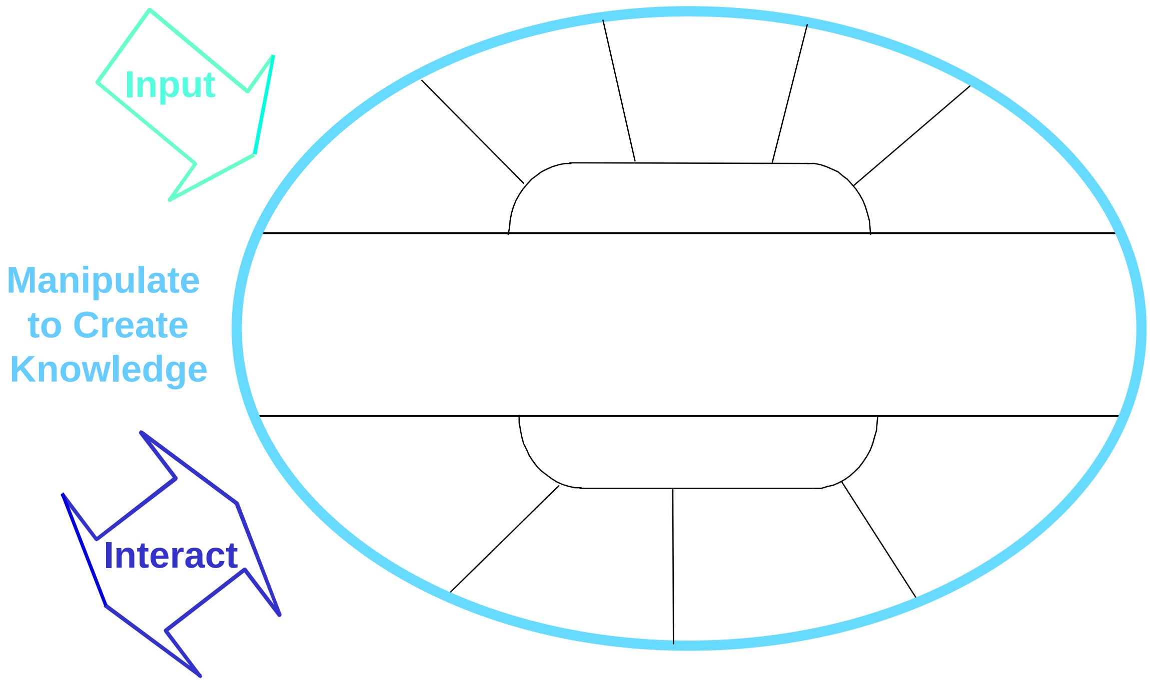


Figure 2-2. *Component Functions of the Battlespace InfoSphere*

2.4 The Input Process

For information to be useful, it must be available to those who need it. In the BI, information is put *in* from a variety of sources. While not physically present in a single system, information is present as an *object* in an *information space* within the BI. Some specific sources for information contained in the BI are indicated in Figure 2-3. While not a comprehensive listing, it does represent some of the more pertinent sources of information for the conduct of combat operations.

2.4.1 Combat Support Products

Combat support products are those that are compiled by systems not directly involved in the planning and execution of combat operations. Examples include fuels, munitions, supply, medical, and personnel systems that make sure that the right people and resources are available and provide these same resource constraints for planning. These systems are integrated into the BI and do not require the manual transfer of information between the individual systems and the planners' and operators' systems.

2.4.2 Fusion Products

While raw imagery and intelligence data will be available within the BI, the fused data and analysis will be available as the result of intelligence systems connected to the BI. As with all the information in the BI, access to this type of information may be limited based on the commander's intent.

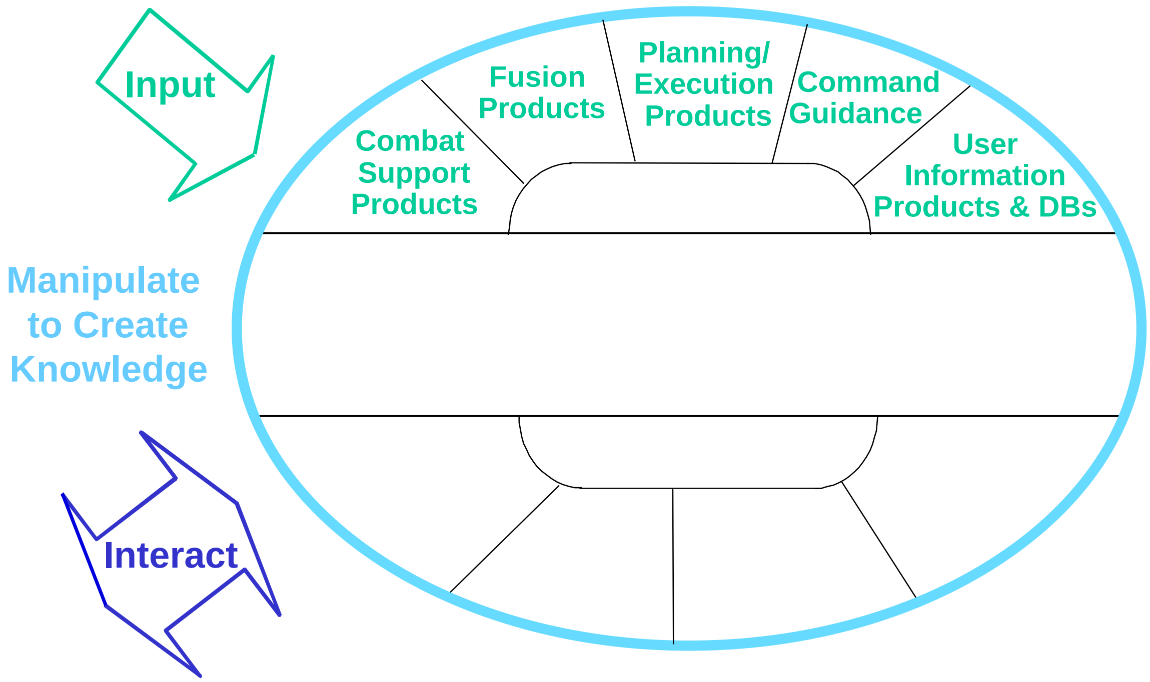


Figure 2-3. *The Input Process*

2.4.3 Planning/Execution Products

Planning and execution products must also be placed in the BI. As the means for transmitting original plans and execution orders, it is obvious that both of these require input actions. In addition, a closer interaction between these will permit real-time updates to plans based on execution results and real-time updates to execution orders based on revised plans.

2.4.4 Command Guidance

The BI must be capable of capturing the commander's intent and permit that intent to be carried out. As with all other information in the BI, a mechanism must be present to allow it to be placed in the BI. The interactions between many of the other systems are dependent on the commander's input to the BI.

2.4.5 User Information Products and Databases

Other information sources, such as weather reports, news feeds, and maps, will be accessible from the BI. Some examples of these input actions to the BI are:

- A report is produced by someone using the BI
- It is necessary to search the Web for some background information
- Some external database must be used to gather needed information

Regardless of which of these actions take place, the results of the action become information or a data object within the BI and require a method of placing that information in an *information space location* available to the BI.

2.5 The Manipulation Process

Once information is placed in the BI, it can be manipulated to derive new information or knowledge. The panel feels that information manipulation is encapsulated within five processes: (1) the publish process puts information into the BI as an object, (2) other systems and human operators are notified of the published information automatically through a subscribe process, (3) at the same time, published information can be automatically changed into a new representation or combined with other information via a transform process, (4) a user or system that doesn't subscribe to a particular information object can still access that object using a query process, similar to a web search or database access, and (5) the internal operations of the BI can be modified and tuned using control processes.

These processes are identified in Figure 2-4. They are described in greater detail in Chapter 3.

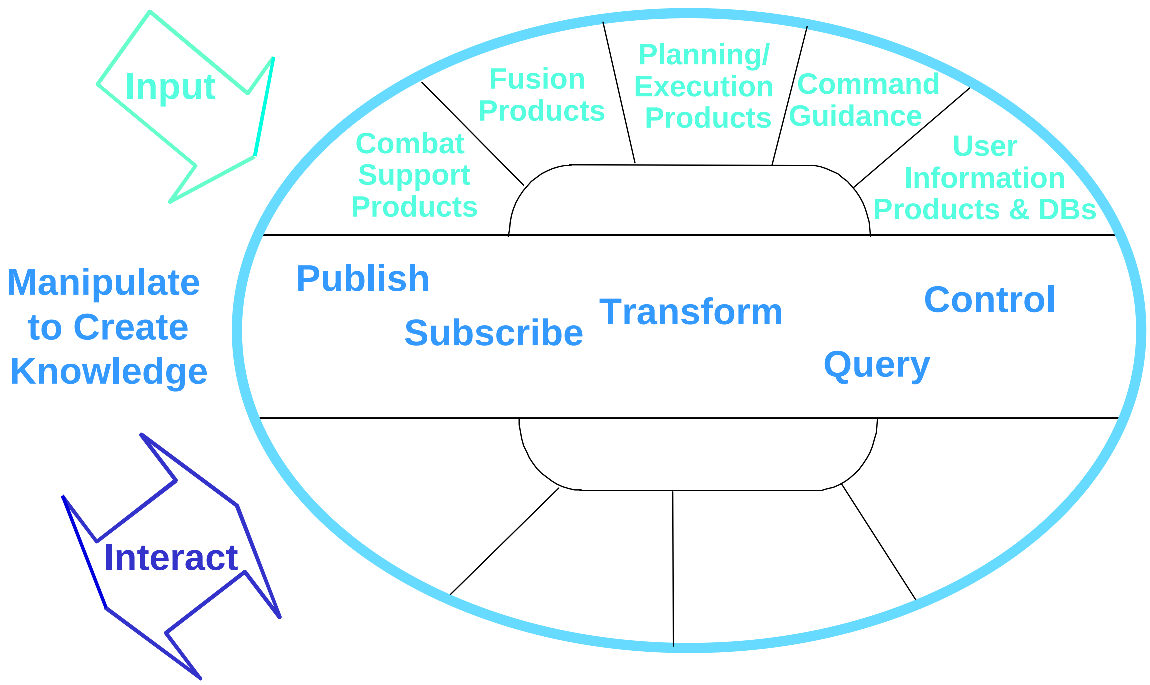


Figure 2-4. *The Manipulation Process*

2.5.1 Publish

When an information object is created, it is made available to other people or processes in the BI by publishing. This action makes the object instantly visible as well as tags the information with the source of the information, the time it was created or modified, the time stamp of the raw information it is based on, the geospatial coordinates associated with the object, and any other data that can be used to identify those who would be interested in the data or who contributed to its creation. Publishing is the primary method of putting information *into* the BI.

2.5.2 Subscribe

When an information object is published in the BI, those people who subscribe to the published information are immediately notified of the published object. A subscription is similar to a

standing query for information matching certain characteristics. A subscription can be as general as subscribing to all information about a single topic (for example, Iraq) or geospatial reference location (for example, all information tagged to within 10 km of 42 N by 19 E). It can also be very specific to the same sorts of information tags (for example, the status report for fuel at Aviano Air Base).

2.5.3 Transform

Information can also be transformed from one format to another. This can be automatic or instigated manually. For example, the execution order produced by the C^2 system of an Air Operations Center (AOC) may not be compatible with the display in a fighter aircraft in its original form. This order can be transformed automatically into a format compatible with the systems on board the aircraft. On the other hand, a report from a field agent may be reviewed and tagged with a level of confidence by an intelligence analyst. Actions that change the attributes or contents of an information object or that combine an object with other objects to produce new objects are transforming actions.

2.5.4 Query

The BI can be searched for information just as the Web or a database can be searched. This is a query operation that allows people or systems that do not subscribe to some information object to access and use that object as necessary. It differs from the subscribe mechanism in that it must be initiated by the requestor of the information, a “pull” rather than a “push” of the information.

2.5.5 Control

Like all complex systems, the BI must be maintained while operating in a dynamic environment. The control processes allow its operation to be tailored for performance, bandwidth allocation, security, data management, and other characteristics affecting its proper functioning.

2.6 The Interaction Process

People and systems interact with the BI to provide the operations shown in Figure 2-5. These operations vary in their complexity and in the extent to which they are embedded within the BI or are services provided by the BI in conjunction with external, connected systems.

2.6.1 Decision-Centric Presentations

One method of interacting with the BI is through presentations geared toward the decisionmaker. The display may be specific to an individual or to the position and types of decisions being made. For example, by interacting with the BI interface, the commander can approve a target that has been selected by another process or person within the BI, and the planning and execution systems will be automatically updated.

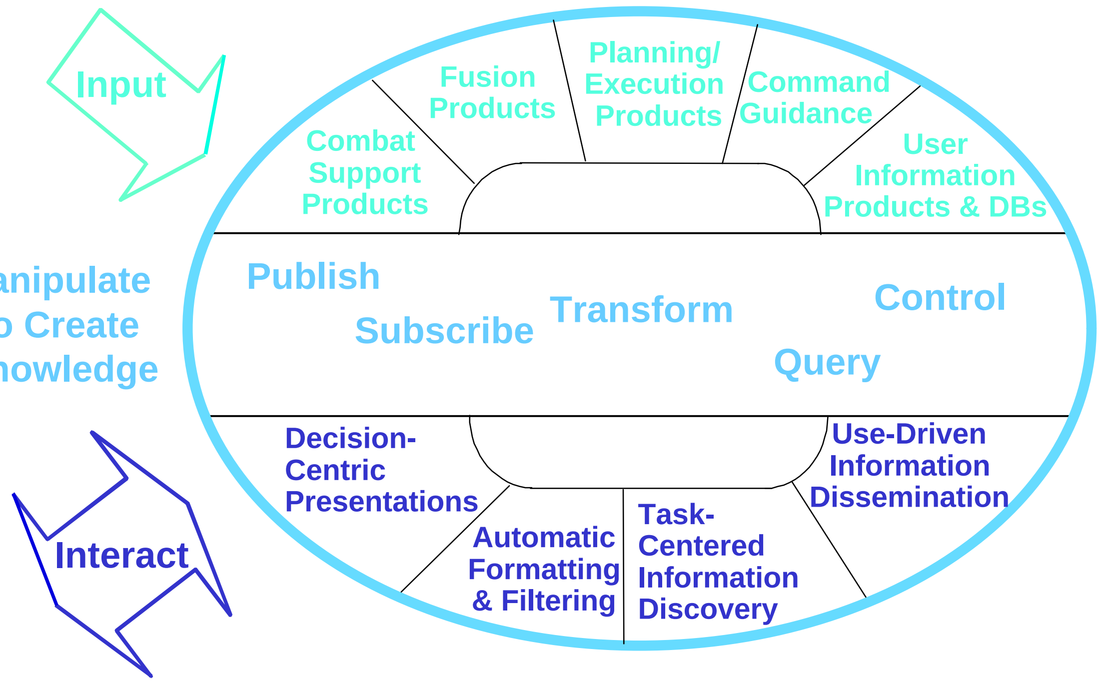


Figure 2-5. *The Interaction Process*

2.6.2 Automatic Formatting and Filtering

Objects published in the BI must be formatted for compatibility with the format expected by the person or user interacting with the data objects. This is especially true of legacy systems that rely on the BI to provide input and output services to and from other information systems. In addition, there is a need to format and filter information based on the relative display requirements and information requirements of the person who needs the information. For example, while the target planner and the strike pilot need to know many identical things about an assigned target, the pilot's display is not capable of displaying all the same information, so the information must be filtered and formatted to provide the appropriate display (this is also an example of a decision-centric display).

2.6.3 Task-Centered Discovery

As the BI operates, unexpected relationships that indicate useful information may be identified. Just as an increase in the number of pizza orders at the Pentagon may have a discovered relationship to the conduct of contingency operations, other information objects may have as-yet-unknown relationships that can drive the interaction with the BI. A BI for a foreign government might push data about the pizza orders to a person or system even though that information was not subscribed to or queried. These relationships will depend on the tasks being performed by the person or system and on the observed or discovered relationships.

2.6.4 Use-Driven Dissemination

Interaction with the BI will depend on the users of information. Rather than broadcasting large amounts of information and expecting the people at the other end to wade through 10,000 e-mail messages and thousands of pages of information to discover the pieces they need, the BI will

forward to them only the pieces they need, without an explicit subscription or query for the information. This reduces the information overload experienced by users in a "push" system, or in a "pull" system such as a Web search engine.

2.7 The Amplified Functions of the Battlespace InfoSphere

The key factor in developing the BI is the underlying representation of the information. Information input into the BI must have a common representation to allow all of it to be manipulated in a uniform way. This common representation is the basis for the publish, subscribe, transform, query, and control operations associated with the BI. As shown in Figure 2-6, the common representation is the glue that allows the integration of all the different input sources and interaction techniques to handle the same information.

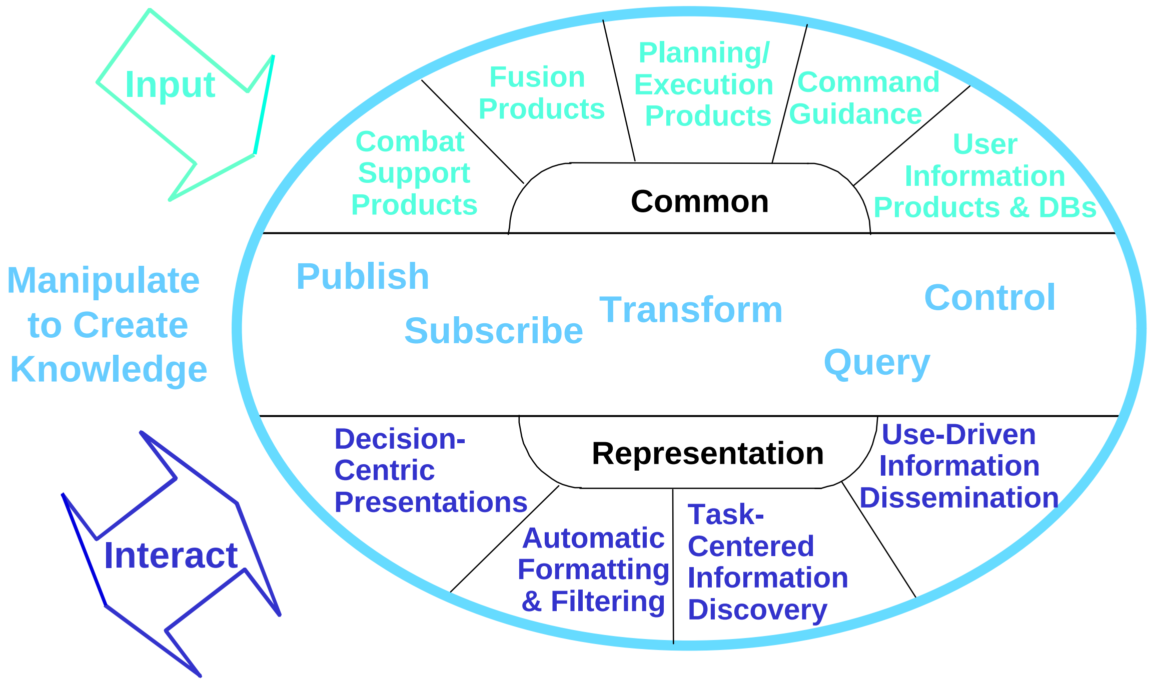


Figure 2-6. *The Battlespace InfoSphere Common Representation*

The BI provides the *right* information at the *right* time, disseminated and displayed in the *right* way, so that commanders (and "crew chiefs") can do the *right* things at the *right* time in the *right* way. The objective: interpret information and make decisions faster than the other guy, thereby ensuring *information superiority*.

2.8 Summary

This chapter defined a functional view of the BI. Chapter 3 will explain the architecture of the BI, while Chapter 4 will provide a more detailed vignette describing the operation of the BI in a combat environment. Chapter 5 will discuss technologies. Chapter 6 will discuss implementation, and Chapter 7 will provide the panel's recommendations.

Chapter 3: Battlespace InfoSphere Architecture

3.0 Battlespace InfoSphere Architecture

The BI, as outlined in previous sections, is an extension of the capabilities of network-connected C^4I components of network-centric warfare. It is a dynamic, distributed, real-time system that provides database and communication services. It provides up-to-date information to all people and systems associated with conducting a military operation or combat.

The BI comprises objects that encapsulate knowledge about the battlespace and that are created and exist within the information realm. During an object's lifetime there are three main types of actions that can be performed: *input*, *manipulate*, and *interact*. Objects are *input* into the BI from various sources and made available for manipulation within the BI. Objects are *manipulated* in the BI by five actions—publish, subscribe, transform, query, and control. Once in the BI, objects can also *interact* with entities outside the BI, such as people, legacy systems, and external databases. The high-level descriptions of these activities are provided in previous chapters. This chapter describes in greater detail the basic concepts and services that compose the BI architecture, shows how they provide a powerful framework for tactical IM, briefly describes some implementation suggestions, and points out risks and challenges that must be addressed to build a successful BI.

3.1 Basic Concepts of the Battlespace InfoSphere

The core features of the BI are based on the concept of manipulation to create knowledge, described by Figure 2-4. This concept is composed of the ideas of publishing objects in the BI so that they can be shared with others; subscribing to objects to be made aware of the most up-to-date information available; transforming objects into new objects, representations, or aggregate objects; enabling queries to find information within the BI; and controlling the operation of the BI to ensure that it is correct and robust.

The *publish* and *subscribe* mechanisms are the key to the BI: they provide the means for communication among systems and people, and they provide a record of published information that can be queried or analyzed later. But unlike book or newspaper publishing, BI publish-subscribe transactions can operate very fast so as to form sensor-to-shooter connections and other real-time linkages. The publish-subscribe mechanism suffices to provide the wide range of communication and system-integration functions needed by the BI. To amplify on the design of the BI, the following subsections discuss four important aspects of the design:

- Information objects obeying standard definitions
- Use-driven object routing and sharing via publish-subscribe
- Transformation and aggregation via fuselet processing
- Control of BI functions

3.1.1 Information Objects Obeying Standard Definitions

The BI stores structured *information objects* that record battlespace information. These objects might be likened to electronic forms, where the form is rigidly structured to record, in separate named fields, all the information required to describe the object. For example, a battle damage assessment (BDA) report is a form that gives the identity of the target that was hit, the time and method of observation, the damage assessment coded in a standard form, and perhaps other commentary prepared by an analyst. Some of the fields of an object have rigid formats—for example, a specification of position or time that can be processed automatically by software—whereas other fields may contain text to be read only by humans. These objects are in some ways similar to records in a relational database system.[*]

Every BI object must conform to a standard definition. That is, all objects that serve as "BDA reports" must use field names and conventions established for objects of that type. This is necessary so that all software that publishes and subscribes to BI objects can interpret the objects in the same way. Determining the universe of BI object types required to support a battlespace is an important part of the BI design; some examples are given in Table 3-1. Moreover, it may be necessary to introduce new BI object types as an engagement proceeds. One of the roles of the BI will be to hold a registry of BI types and their definitions. People as well as computer programs can query the registry to determine how to interpret new object types.

Table 3-1. *Some Examples of the Types of Objects Found in the BI*

Some military BI object types	**Some generic BI object types**
Electronic order of battle	Document
Weather forecast	Spreadsheet
Force readiness report	Image
BDA report	Video feed
Defense News Network feed	Message
JointSTARS MTI track report	
Base status report	**Some mission-specific object types**
Commander's intent	AOR-specific NIMA image
Analyst report	COMINT recording from a collection asset
Air tasking order	Aerial ports database entries for the AOR
User profile	

In many cases, BI object types are trivially derived from existing types. The generic BI object types listed in Table 3-1 will almost certainly use definitions that are consistent with existing COTS software or Internet definitions. Thus a video feed prepared by a commercial continental United States (CONUS) news service can, if it is appropriate, be made available as a BI object.

[*] Unlike objects in an object-oriented programming language, BI objects do not have "methods" or "code" associated with them that specifies how to process the objects. Instead, the object type is interpreted by each subscriber to determine how to interpret the object's fields. The biggest challenge will be agreeing on the common metadata which will make it worthwhile.

Each BI object must have some associated *metadata*—data about the data. As an everyday example, metadata about a book includes its publication date, the name of the publisher, the name of the author, subject keywords, the International Standard Book Number, and so on. This information is commonly available in a library catalog to help the reader find a book. Metadata for BI objects is required for the same reason: for responding to queries and for determining whether an object should be passed to a subscriber.

Table 3-2 shows schematically an example of a BI object and its metadata; note its similarity to a paper form. The leftmost column gives the names of the metadata fields, sometimes called *tags*. The second column gives a value for each tag. This object contains information about potential enemy forces; its type is *Enemy-Force-Report.* The object-ID is assigned by the BI to uniquely identify this object. The geotemporal reference provides a standard way for every BI object to specify a time and region of space associated with the data. For example, a weather forecast might give a spatial region that it covers, or a moving-target indicator (MTI) track might specify a region spanned by the track. Other tags identify the provenance of the object. One tag in particular, referred to here as *sources,* identifies other BI objects used to derive this one; these might be unmanned aerial vehicle (UAV) video recordings, satellite imagery, or other analyst reports used as source material in preparing this report. These source objects allow applications to drill down to see evidence supporting derived information.

Table 3-2. *A Schematic Representation of a BI Object*

<type>	enemy-force-report	
<object-id>	BI-Bosnia/145643	
<geo-temporal-reference>	1998 220 1740.32 [44.522N 18.344E 0]	
<created-by>	user-77456 1998 220 1755	
<security-class>	Bosnia-local	
<sources>	BI-Bosnia/107782 BI-Bosnia/78443	
<object-content>	<force-type>	scud TEL
	<status>	stationary
	<observation-type>	unmanned aerial vehicle-video
	<comments>	This transporter-erector-launcher may be out of action due to damage because others in the vicinity have moved and it has not.

The example continues to show the fields of the *enemy-force-report* object itself: *force-type, status, observation-type,* and *comments.* Each of these fields has a limited set of allowed values; the *comments* field can contain arbitrary text. This example is very sketchy; an actual BI object would have a more comprehensive set of metadata tags as well as a more complete set of object

content fields. The essential property of BI objects is that their definitions must be standard and accessible in the registry, thus permitting all BI participants to process them uniformly. For example, the *geo-temporal-reference* tag is recorded in the same way for every BI object so that queries can find all objects that provide information about a particular region in space and time.

3.1.2 Use-Driven Object Routing and Sharing Via Publish/Subscribe

The most powerful mechanism within the BI technical architecture is the concept of "publish and subscribe." When a new object is created as a result of new information acquired or interaction with warfighters using the processes illustrated in Figure 3-1, the object is "published" to the BI database. This step makes the object instantly available to people and processes that access the database. These BI participants will usually "subscribe" to such objects by specifying the essential properties of objects they seek. Thus the publish-subscribe mechanism forms communications links between the providers of information and the seekers of information. The essential feature is that the linkages need not be known in advance: new subscriptions can be established at any time by people or BI processes that need information. The communication is thus use-driven.

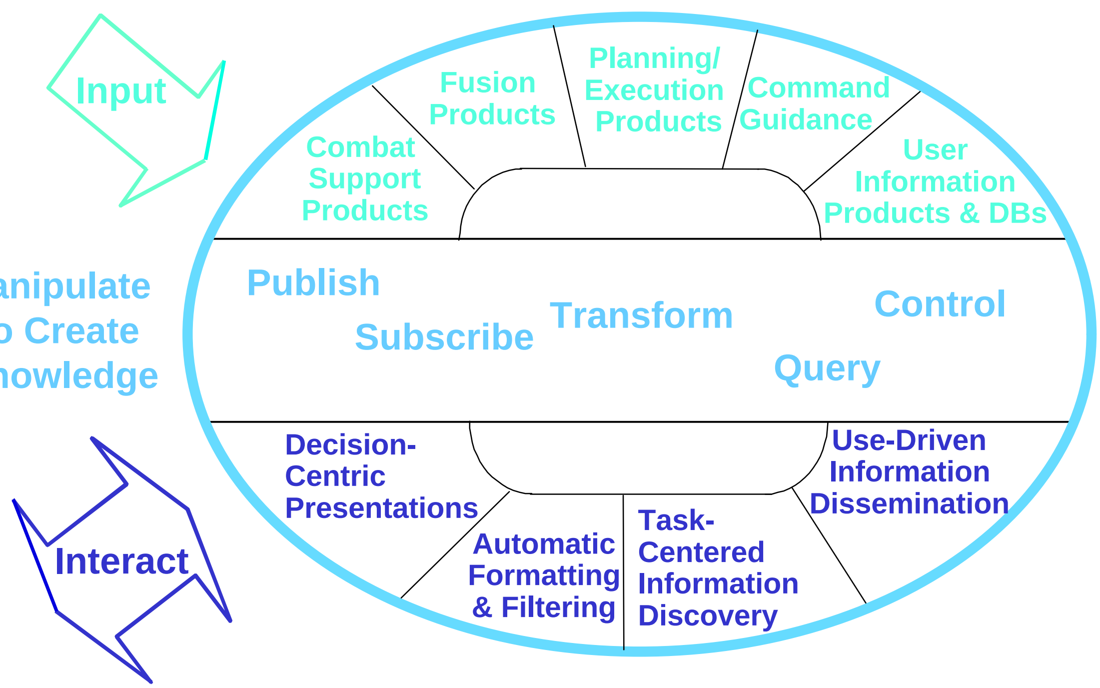


Figure 3-1. *Information Published Through the Battlespace InfoSphere*

A subscription is similar to a database query: it specifies the kind of data it seeks. Generally, subscriptions specify metadata values that must match corresponding values in newly published objects. For example, a subscription seeking objects of type *enemy-force-report* with a *geo-temporal-reference* that intersects a circle of radius 10 km centered at 44°53′ N, 18°38′ E would match the object depicted in Table 3-2. Subscriptions cannot inspect the contents of objects, only their metadata tags. For this reason metadata tags must be standardized and associated with every BI object when it is published.

Publish-and-subscribe provides an “object switchboard,” enabling the routing of newly created objects to information-processing functions that need such objects as inputs. These functions may in turn publish new objects to the BI. In this way, BI processes are connected by publish-subscribe links to form automatic information flows that process the battlespace information.

3.1.3 Transformation and Aggregation Via Fuselet Processing

While the publish-subscribe mechanism routes objects from their sources to their seekers, the collection of BI processes actually performs information-processing activities such as fusion, aggregation, and filtering. The panel has chosen to name these subscription-driven processes *fuselets* (see Figure 3-2), recognizing that a common application of such processes is to fuse data from several sources into information. The fuselet enters one or more subscriptions collect the information it needs. Whenever a new object is published that matches a subscription, the fuselet process is triggered and executed. The fuselet may examine the newly matching object and determine that it is not relevant to the fusion task for which the fuselet is responsible; subscriptions provide a coarse filter on objects, but only the subscriber can examine the details of the object fields and make decisions. If, on the other hand, the fuselet determines that it should issue new results, it publishes a new object to the BI, which in turn may trigger other fuselets.

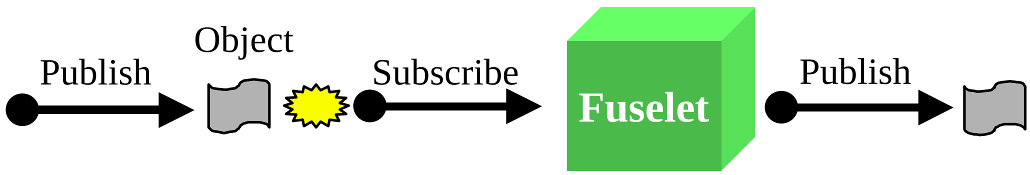


Figure 3-2. *Information Flows Using Publish, Subscribe, and Fuselet Processing*

As shown in Figure 3-3, fuselets have many uses: they can bring information into the BI, transform sets of BI objects into aggregated objects, or gather objects for presentation and automatic report generation. The inputs to fuselets are typically subscriptions to BI objects, and the outputs, where needed, are typically in the form of the publication of further objects.

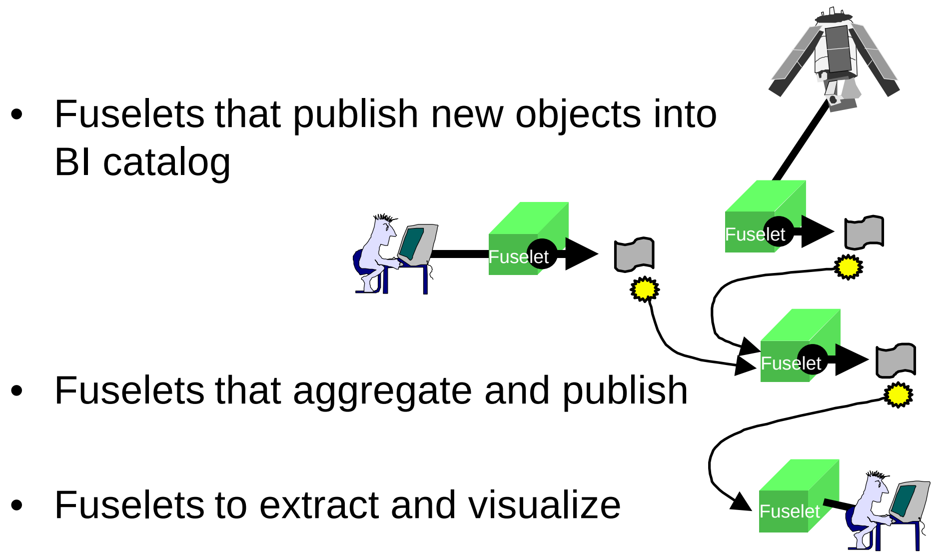


Figure 3-3. *Different Uses of Fuselets Linked by the Publish-Subscribe Mechanism*

The term *fuselet* is intentionally coined to connote the more familiar concept of the Java™ applet. There are two key points of this analogy: First, just as applets conceptually “live on the net” rather than residing on a particular machine, so too are the fuselets to be thought of as “disembodied”—that is, the fuselets are mobile code or functions with access paths stored in the BI. Second, just as applets may be anything from simple collections of library functions to larger programs that perform complex processing, so too fuselets can be very simple in many cases.

Fuselets can be created using either custom scripting languages or standard programming languages. The standard services described above, such as subscribe and publish, are available for use in the fuselets as library objects. In addition, fuselets can be named and published as library objects, so they can be accessible for use in other fuselets.

Fuselets take on many forms. Any computer program that uses the publish-subscribe mechanism and information object standards of the BI is a fuselet. Fuselets cover such processes as:

- *Legacy applications*, such as major systems for planning, execution, or surveillance. When these existing systems are fitted with software interfaces to use the BI publish-subscribe mechanism, they become fully capable BI processes (see Figure 3-4). The BI also becomes a way for one legacy application to obtain information from others. Although fuselets don’t make it any easier to wrap legacy code than do other interoperability techniques, they do make it easy for wrapped applications to interoperate with the BI and with other BI applications.

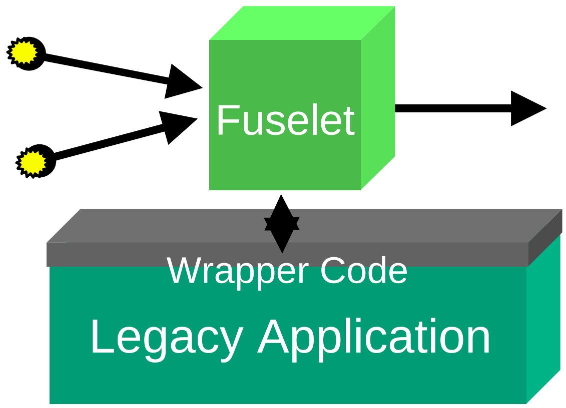


Figure 3-4. *A Fuselet Interface on a Legacy System; the Communication Between the Fuselet and the Legacy System Is Private, not Part of the BI*

- *BI browser*. This term refers to an interactive program that is similar to a World Wide Web browser but adapted to work in the BI. The browser displays pertinent BI objects and uses subscriptions to detect when the objects change so that the browser can update its display. In this way, an analyst or commander can customize displays easily. Analogously, a browser can be used to publish new information in the BI—for example, posting an object that describes the commander's immediate objectives or the analyst's most recent report.
- *Information gateways.* Fuselets can obtain information from public, commercial, or coalition data sources and republish it for use in the BI.
- *Custom processing.* The term *fuselet* was chosen to emphasize this class of processes: simple processing for filtering, aggregating, or fusing information. Often these fuselets will be specified by simple scripts or transformation rules created by a commander and staff in order to adapt to changing information needs.

Here are two scenarios that illustrate how fuselets might be used to help a commander collect needed information:

> Three airbases are participating in an engagement. The commander wants to monitor, on the display, a single summary indication of the status of these bases. The commander's staff creates a fuselet that subscribes to all objects of type *base-status-report*, runs a script to extract the value of the field *status-indicator* from each base's report, and publishes a new object of type *commander-base-status-summary* that has a single *status-indicator* field to specify the combined status. The commander's rule, implemented in the fuselet script, is "if any base status is YELLOW, and no base status is RED, then the overall base status is YELLOW" (see Figure 3-5).

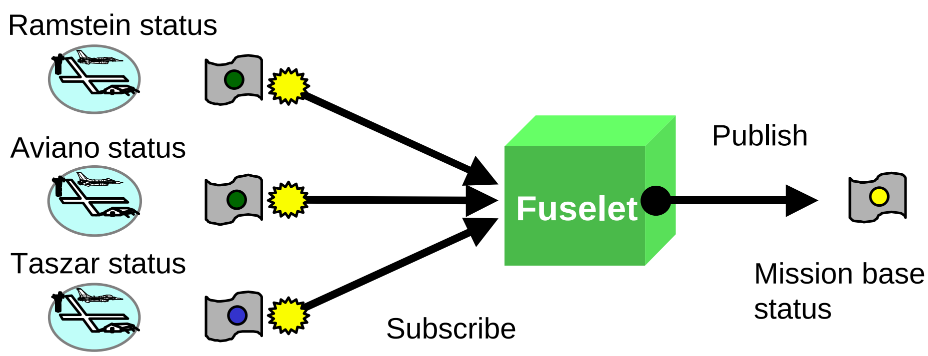


Figure 3-5. *A Fuselet Automatically Determines and Publishes Mission Status*

The scenario in Chapter 4 uses the BI to provide an automatic sensor-to-shooter linkage to kill an enemy missile. The area commander, however, wants to be informed when such events occur. The commander directs his staff to prepare a fuselet that subscribes to the execution order created by the fuselet shown in Figure 3-6, and creates an alert on a display in the AOC.

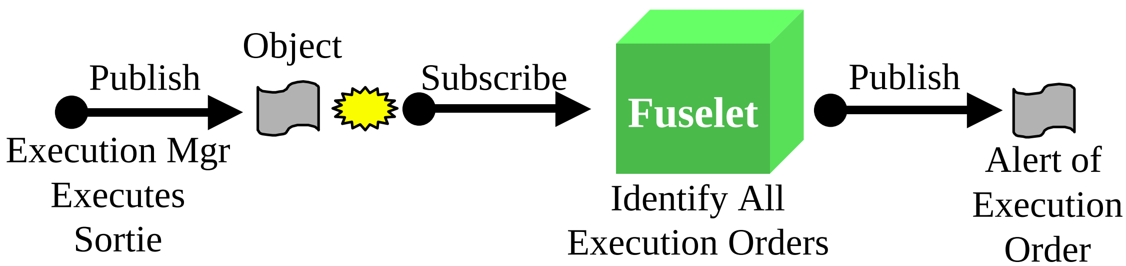


Figure 3-6. *The Publish-Subscribe-Publish Cycle*

Fuselets may be completely automatic or may interact with humans. Some fuselets serve as data-entry applications, by which users enter information to be published as BI objects. For example, an officer could issue an execution order by entering the necessary information into a fuselet that then publishes a corresponding object. Other fuselets present visualizations of BI objects. Still others may require human intervention—for example, to confirm an execution order that has been prepared by an automatic C^2 system before it is published in a form that will cause the order to be executed.

Note that fuselets may query the BI database. A query is like a subscription in that it matches metadata tags, but returns a list of objects that satisfy the query without automatically triggering any fuselet processing. For example, a query might seek any objects published in the past 30 minutes with a geotemporal reference including a specific target site.

3.1.4 Control of BI Functions

The BI must maintain at all times a real-time, situation-aware, dynamic picture of the battlespace. A set of management and control functions is required to keep the BI operating smoothly and correctly. These tools monitor and control such aspects as:

- Performance: monitoring response times for data transmission and processing to ensure that "the right information is available at the right place at the right time."
- Bandwidth allocation: carefully controlling the use of slow links to airborne platforms to ensure that mission-critical traffic gets through.
- Security: implementing and managing access controls and policies.
- Data management: establishing and monitoring policies for storing BI data. It may be necessary to move or replicate data for efficient access.
- Configuration: specialists may need to change the configuration of the computers and networks that compose the BI in order to provision a BI and to address performance problems. For example, if a server becomes overloaded, it may be necessary to bring another server online and configure it to share the load of the burdened machine.
- Repair: repairing data and restoring service if a BI object or database becomes corrupted. If portions of the BI infrastructure become unavailable due to combat damage, workarounds must be developed.

Operating the BI smoothly will require a staff that is savvy not only about the technical implementation and operation of the BI, but about the design of the information flows required for the mission the BI is supporting. When the flows must be modified or repaired, specialists will need to be conversant with both the military and information-processing requirements. A major goal of the BI is to support experimentation and evaluation of new concept of operations; this will require that BI operations be understood and easily modified by a mission's staff.

3.1.5 Evolution of Command and Control Functions

One of the key advantages of the BI approach is that it provides an attractive evolutionary path for function-specific systems. Today's stovepiped function-specific systems can continue to be enhanced, making improvements within their discipline. Moreover, specific system-to-system integration can proceed, using existing network-centric approaches. The BI and the mechanisms described above offer a way to evolve these function-specific systems.

Functions can be gradually shifted to the BI. Once the existing systems are outfitted with BI interfaces, they can publish their information products to the BI, where fuselet processes can integrate this information with that from other function-specific systems or BI participants. This evolution can be viewed as incrementally building the BI or as extending the stovepiped functions in the BI rather than within the existing stovepipes.

The ultimate vision is that today's function-specific systems have evolved into BI processes and fuselets. The new structure will perform the same (or augmented) functions, but will, by virtue of its BI interfaces, be accessible to new automation and integration opportunities. Key algorithms, such as sophisticated image-processing and decision procedures for extracting tracks

from radar images, will probably be retained as unitary processes—that is, they will not be broken down into separate BI components. However, the inputs to such procedures, the outputs, and the parameters that control their operation may all be accessible through BI objects and the publish-subscribe automation. The idea is to use BI information flows exactly when flexibility is required for integrating information or processes to meet different mission needs, not to "reprogram" the algorithms currently embedded in sensor, fusion, or weapon systems. The BI is for integration, not for systems programming.

3.2 Battlespace InfoSphere Services

The BI contains a set of standard processes that provide the services necessary for creating and controlling a mission-specific BI, as well as for publishing and subscribing to BI objects. Some of these services are intended for direct use by computer programs (for example, publish-subscribe services), while others are provided by tools that are operated by people with the responsibility for managing the BI.

3.2.1 Object Definition Services

The BI contains a repository of object definitions and provides tools for finding object definitions and creating new object types. During the course of a mission, it may be necessary to define new object types and ensure that these definitions do not conflict with others.

3.2.2 Publish-Subscribe and Query Services

The central service of the BI supports publishing and finding objects by subscription or query. When a BI participant wishes to publish an object, it uses the Global Grid network to contact a suitable BI publication service that maintains a catalog of published objects. The service also maintains a list of pending subscriptions. When a new object is published, it is matched against the list of subscriptions to see if any are triggered; thus the test is one new object against all pending subscriptions. Processing a query is similar, but the test is one new query against all published objects.

The catalog will probably be distributed among more than one server machine for both redundancy and performance. Redundancy is achieved by entering the object or subscription in more than one catalog; performance is achieved by segregating objects of different types or performance characteristics on different servers (this "channel" notion is discussed more fully below).

3.2.2.1 Links

The publish-subscribe service must store an object's tag, because this is the information used to match subscriptions and queries. However, the BI need not store an object's contents. When an object is very small, such as the example in Table 3-2, the BI will probably record the object contents as well as the tag. Similarly, the BI will store entire objects in cases where fast response is required. However, an object's contents can be very large (for example, a satellite image or a video feed) and will be retained by the process that publishes the object. In this case, the BI catalog retains a link (or "access path") to the object; to obtain the object itself, a BI participant uses the link to get the object from the original source. (The uniform resource locator [URL] familiar to any user of the World Wide Web, is an example of such a link.) This strategy is used

to avoid transmitting and storing bulky objects that may never be used. It also allows data from external sources to be “imported into the BI” merely by publishing a suitable BI object with a link to the external data.

Access paths that locate objects can be quite general. This access path could be a URL, a string that represents the input to be sent to the wrapper around some legacy system, the structured query language that will pull the information from a particular image database, or any other computer-readable encoding that can be used to get the data to the user. Knowledge interchange languages, such as the “knowledge query manipulation language” developed under Defense Advanced Research Projects Agency (DARPA) support or various languages being explored for database interoperability, are also candidates for these encodings.

3.2.2.2 Channels

The BI must be designed to accommodate a wide range of performance demands. On the one hand, the BI will contain a very large number of objects. On the other, sensor-to-shooter publish-subscribe links must be processed very fast to be effective. When a fighter subscribes to objects about attacking missiles in its flight path, that subscription should not have to consider news stories published into the BI about political events in surrounding countries! For this purpose, the BI is segregated into separate collections of objects, called channels (see Figure 3-7).

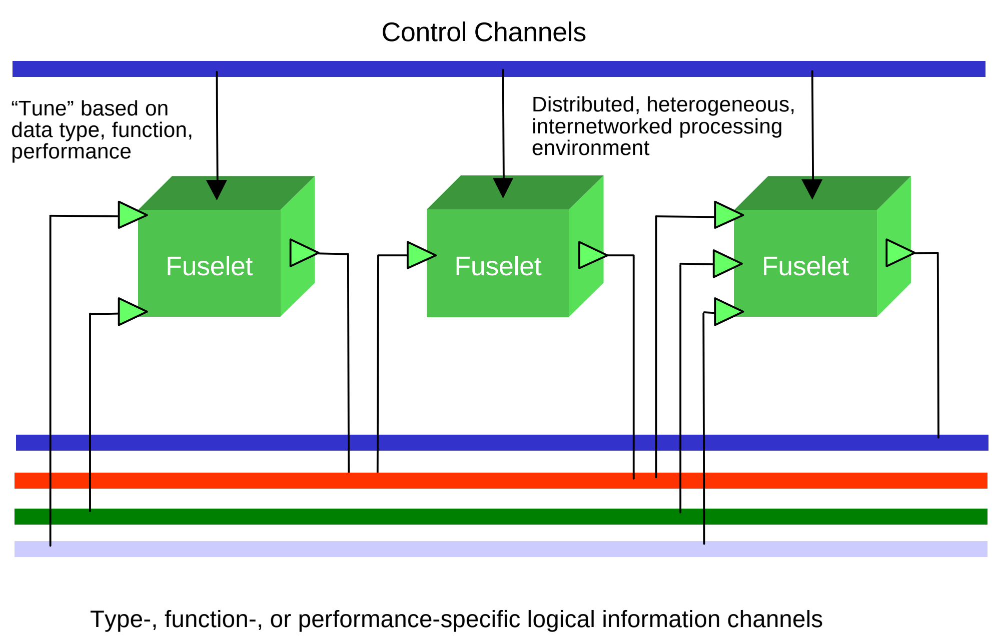


Figure 3-7. *A Schematic Representation of Object Channels Used to Segregate BI Traffic*

When a BI is established, separate channels are set up to carry different traffic. Then when each fuselet is configured to operate in the BI, it is told which channels to use for publication and subscription. Fuselets in sensor-to-shooter loops will use a channel that has little other traffic; there may be a dedicated sensor-to-shooter channel for each fighter wing to further reduce traffic. By contrast, fuselets that deal with materiel and supplies can use a channel with a larger,

more diverse object population and correspondingly slower response. Queries may need to be directed to specific channels as well, and it may be necessary to control query access to high-performance channels to avoid reducing the speed of publish-subscribe links.

The channel mechanism can be used to manage traffic in various ways. Channels might be used to make type-specific partitions, function-specific partitions, or performance-specific partitions. For example, all situation reports can be transmitted on a sit-rep channel. Channels may be created by function, such as the command channel, the fusion channel, or the execution channel. Lastly, the channel structure can be exploited for performance differentiation. One channel can be dedicated for flash traffic, another for low-priority “as available” traffic. Channels can also be used for internal BI traffic: Figure 3-7 shows a separate channel used for fuselet control objects.

Channels could be arranged in a hierarchy, so that *publish* and *subscribe* can be directed to groups of channels. For example, suppose there are a low-priority sit-rep channel, a high-priority channel, and an overarching sit-rep channel that includes the other two. A subscription entered on the overarching channel will match objects published on either of the inferior channels. However, this superior channel would provide performance no better than the least-performing inferior channel, so as not to interfere with high-performance inferior channels. In this way, there can be a single “root channel” for a BI devoted to a regional conflict; subscriptions on this channel will detect objects published to any subchannel throughout the BI.

Channels must be used judiciously. They are essential for segregating the very high-performance traffic. However, if too many separate channels are configured, it may become difficult or impossible to decide where an object is—that is, errors will result when an object is mistakenly sent to the wrong channel or mistakenly expected to be on some other channel.

3.2.2.3 Change Detection

Many fuselets will publish results that depend on their inputs and will need to be informed if their input data changes. The publish-subscribe mechanism already provides a measure of change detection. In the example of Figure 3-5, if the status of the Aviano base were to change, a new base-status object would be published; it would match the subscription entered by the fuselet depicted in the figure, and the fuselet would be triggered and would publish a new mission-status object as a result. The change would be detected because the fuselet’s subscription detected the new object.

By contrast, suppose that a fuselet creates an execution order in response to a human intelligence report of enemy activity in a certain spot. Suppose that this report is later found to be inaccurate and that a new report is published. The fuselet might detect the new report with a subscription, but it might prefer to know that the old report was invalidated. For this purpose, the publish-subscribe mechanism can be extended to allow a fuselet to publish the fact that a specific object has changed, and to allow fuselets to subscribe to change notices on specific objects.
A key technical decision in the design of the BI is whether objects must be “immutable,” that is, cannot change once they are published. If object contents can be changed without changing the object’s identifier (as is the case with mutable objects), then “version” is required to ensure that new versions supplant old versions. However, a mutable-object design makes it easy for fuselets

to detect changes. Immutable-object designs result in many more objects (in effect, all old versions are kept) and in problems with deciding when a new object replaces an old one.

3.2.3 Establishment Services

These are the services used in provisioning a mission-specific BI. They provide automated help for gathering sets of information from standard data sources (such as military databases, national image archives, and digital terrain data) and for publishing these into the BI. These services also support the downloading or linking of objects that are thought to be critical within the area of responsibility (AOR), including open-source Internet sites or other nonmilitary background data that the command deems useful.

3.2.4 Access Control Services

The military nature of the information in the BI demands strict ability to control the access to data. The access control services are used to define who may retrieve or subscribe to which data and BI object types and at which levels of classification. In addition, the BI provides some specialized services to allow for the tracking of “pedigrees” on the information. These services are used to provide automated assistance to applications that maintain those object tags that concern authorship and ownership of BI objects. Thus, for example, an application could allow a user to register as the “owner” of a particular object and then be informed whenever someone else subscribes to or retrieves that object.

3.2.5 Data and Bandwidth Management Services

An important aspect of operating the BI during a mission is the ability to control the flow of information, making sure that high-priority information propagates through the system rapidly and that bandwidth is not swamped. In the BI, a key factor in controlling this information flow is the task of making sure that important, frequently accessed information is stored close to its point of use, while large data sets and low-priority items are left to move more slowly. In addition, the reliability of information resources and bandwidth to these sources must be considered in deciding whether it is more efficient and reliable to move information or replicate it. For example, a BI object published on the personal digital assistant of a Special Forces operative will likely be moved to a repository that is more reliable and higher-speed, while a large image BI object might be left in a continental United States repository and moved only on demand.

3.2.6 Performance Monitoring and Information Process Control Services

Maintaining the flow of information, making sure that user-defined functions do not interfere with each other or otherwise cause problems, finding such problems and making changes when problems are detected, and otherwise maintaining the smooth running of a large, distributed information space such as the BI is a difficult task. For example, it may be that a particular piece of information is highly subscribed and causes a bottleneck in the information flow. The data management services described previously will enable the information to be cached at a local server closer to its use or to be copied and distributed to several servers. However, detecting that such a bottleneck is occurring requires the ability to understand what is happening within the information flow. Since such a flow can be highly use-driven and subject to unpredicted fluctuations, the ability to visualize, analyze, and repair flow problems is a crucial need of a BI

information manager. The monitoring and process control services allow applications to be built that let the manager run the BI more efficiently.

When information is invalidated or deemed unreliable, changes must be propagated rapidly through the BI. This is especially important if the change affects a real-time mission in progress. One of the roles of monitoring services is to detect problems with information delivery. Each BI subscriber can determine how fast new information was delivered by comparing the time when the information was created to that when it was delivered. If delays become unacceptable, the subscriber notifies the performance-monitoring service, which can alert BI managers to take remedial action.

3.3 Risks and Challenges

While the concepts of the BI are straightforward and have been tested in previous systems, the size, scope, and mission of the BI pose some new challenges. Before launching a large effort to build the BI, a few experiments should be undertaken to explore the riskier parts of the design. The experiments may indicate areas where research is required to develop technology necessary to implement a full-scale BI. This section outlines some of the principal unknowns the BI design faces; each may require several separate experiments.

3.3.1 Design of "Military Objects" and Information Flows

The success of the BI depends on designing BI object structures that can span the C^2 needs of today's missions and can be interfaced to today's stovepiped systems. The object designs and the information flows implicit in fuselet structures must be understandable by command staff, and the staff must be able to modify flows to suit their needs. Also, it must be easy to add or remove C^2 assets from the flows: for example, if a sensor is available, it should be integrated into the flows, but command decisions must not be impeded if it is not available. Can such an "information design" be done? Related efforts have been undertaken (for example, Common Data Environment definitions), but not with the span or scale required for the BI.

3.3.2 Performance and Scalability

What are the performance requirements of the BI? How many objects per second will be published? How often will new subscriptions be entered? What kind of publish-subscribe traffic can today's servers support? Does the *channels* mechanism adequately address the need for low-latency BI processing? The BI performance requirements are closely related to the design of the BI objects. For example, if each of the thousand or so MTI tracks monitored by a JointSTARS flight were to be published as a separate BI object, updated roughly every 30 seconds, the BI might easily be overwhelmed. Perhaps all tracks should be published as a group, but those individual tracks identified as critical to some mission operation should be published separately as well, so that updates can trigger fuselets that monitor the specified track.

3.3.3 Robustness

How should the BI be designed to withstand disruptions due to equipment failure or errors in configuration? Redundancy can be provided in the network and server architecture. However, a more serious problem is that deliberate changes to the configuration or fuselets while the BI

is operating may inadvertently disrupt information flows that are required for mission-critical actions. Are there ways to test new systems or to roll back to old configurations quickly and reliably? When things do not work, can humans intervene effectively?

3.4 Summary

The BI is based on a set of simple concepts for knowledge creation and manipulation. This chapter explained how these concepts of publish, subscribe, transform, query, and control would operate and interact to provide the capabilities of the BI. The capabilities implemented using these concepts would provide a uniform set of services that could support an evolution from the information systems of today through network-centric warfare to a true integrated BI.

To be effective, the concepts and technologies must be implemented in a seamless way into daily operations. The next chapter presents a short vignette describing an operational scenario that could be carried out with the BI. A description of the support provided behind the scenes by the BI is interleaved with the scenario to help explain the benefits derived from using the BI.

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Chapter 4: Illustrative Vignettes

4.03 Illustrative Vignettes

As the revolution in military affairs continues to gather speed, the Air Force will find its combat operations ever more tightly bound to IM. The increasing complexity of warfare will require the Air Force to rely heavily on information systems that automate key parts of warfighting. It already does this in processes such as air tasking order generation. However, the BI concept moves much further toward dense and richly networked warfare. The BI will be built not with the megalithic software applications of the past, but instead with object-based components, each readily identified with existing or future military platforms, systems, and functions. These software objects are not just simulants for offline study, but actual core elements of the warfighting system.

The BI would be a powerful tool for future Air Force commanders, controllers, and executors. It would also be a simulant of combat operations, used for training and to devise new approaches to combat operations. To better understand the ideas, it is useful to view the technology discussed in this study in terms of *military process engineering.* Process engineering, in both its widely used civilian form and in the domain of military operations, focuses on streamlining and making more powerful the underlying processes of an organization. Process engineering relies on the ability to accurately represent (in software) the domain of an organization.

4.1 Vignette Development

To understand the impact of the BI on the principal military *process*—the conduct of war—the panel presents an operational scenario that demonstrates how the BI could improve operational capability. The scenario is divided into vignettes to help show the relationship between the externally observed military actions and the underlying processes in the BI. The panel is attempting to accomplish two objectives with the vignettes: to envision how military processes can be reengineered in light of modern information systems and to envision the actual objects that make up the BI itself.

The focus is on *process*, and on easily identified functions of the military task of attacking a mobile SAM and TEL. In the depiction of a BI in operation, the focus is solely on critical events and does not attempt to exhaustively portray every BI component that would be present in a real system.

The general outline of the scenario is depicted in Figure 4-1. Blue forces supporting the mission include the BI, an ISR confederation, a flight of F-15Es, and an airborne laser. Assume the existence of needed communication links and computer servers (the network-centric substrate of the BI). Assume the necessary complement of distributed BI software objects is available (onboard as well as offboard). The Red forces comprise a mobile SAM and a mobile TEL. While the scenario resources utilized are possible with current assets, the flexibility, responsiveness, and process underlying it are unique to the BI.

With these assumptions, the scenario then describes how the battle would unfold. Three pairs of figures follow. In each pair, an *operational vignette sequence* describes the military concept

of operations, then a *technical vignette sequence* provides the underlying technical concept of operations.

4.1.1 First Operational Vignette Sequence

As the vignettes open, a flight of four F-15Es is in a holding orbit awaiting tasking. Nearby are elements of the Blue ISR confederation (UAV, JointSTARS, satellites, etc.) that feed the BI, maintaining a common situation representation. On the ground are a Red TEL and a Red SAM. The SAM is not yet detected, and so is not yet in the BI (or COP). The TEL is moving to a launch site. JointSTARS detects the moving TEL, and the F-15Es are tasked to attack it. This is depicted in Figure 4-1.

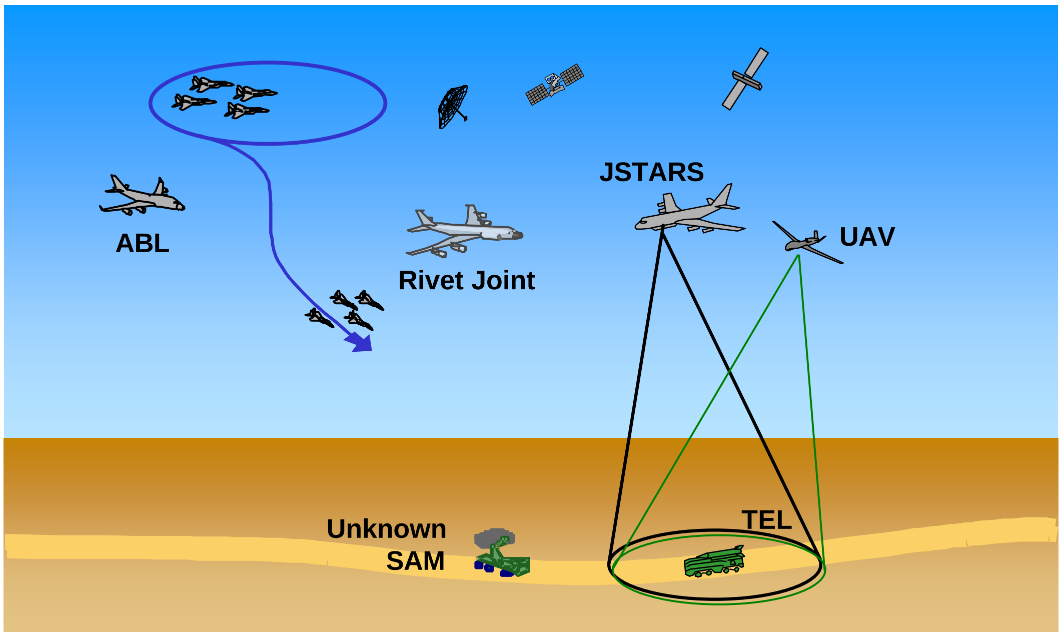

Figure 4-1. *First Operational Vignette Sequence*

4.1.2 First Technical Vignette Sequence

The processing occurring in the BI during the first operational vignette sequence is depicted in Figure 4-2. In the figures, processes depicted by blue boxes are technically fuselets, because they have been equipped to participate in the publish-and-subscribe mechanisms.

1. JointSTARS detects a moving vehicle through ground moving-target indication and, by augmenting its moving-target indicator track with an inverse synthetic-aperture radar snapshot, determines that the vehicle is a Scud TEL while confirming it through an unmanned aerial vehicle electro-optical (EO) snapshot. These sensor returns are fused in an exploitation/fusion system and entered as a fact (denoted "TEL = mover") in the common sit-rep portion of the BI.
2. The sudden appearance of the TEL in the BI is a trigger for the execution manager to spring into action.
3. The execution manager retrieves the COP (containing relevant new information about the TEL) and generates a dynamic execution order for the F-15Es.
4. The execution manager inserts the new plan fragment into the common execution representation portion of the BI, ordering the dispatch of the F-15Es to the target while inserting a new information need into the BI. The collection manager is notified of the new information need (which is to provide direct support to an impending engagement by the F-15Es). At the same time, the F-15E flight commander is ordered to attack the TEL.
5. The F-15E flight leader is notified of the new execution plan. At the same time, an information need is sent to the Blue collection manager to provide supporting ISR assets for the impending engagement.

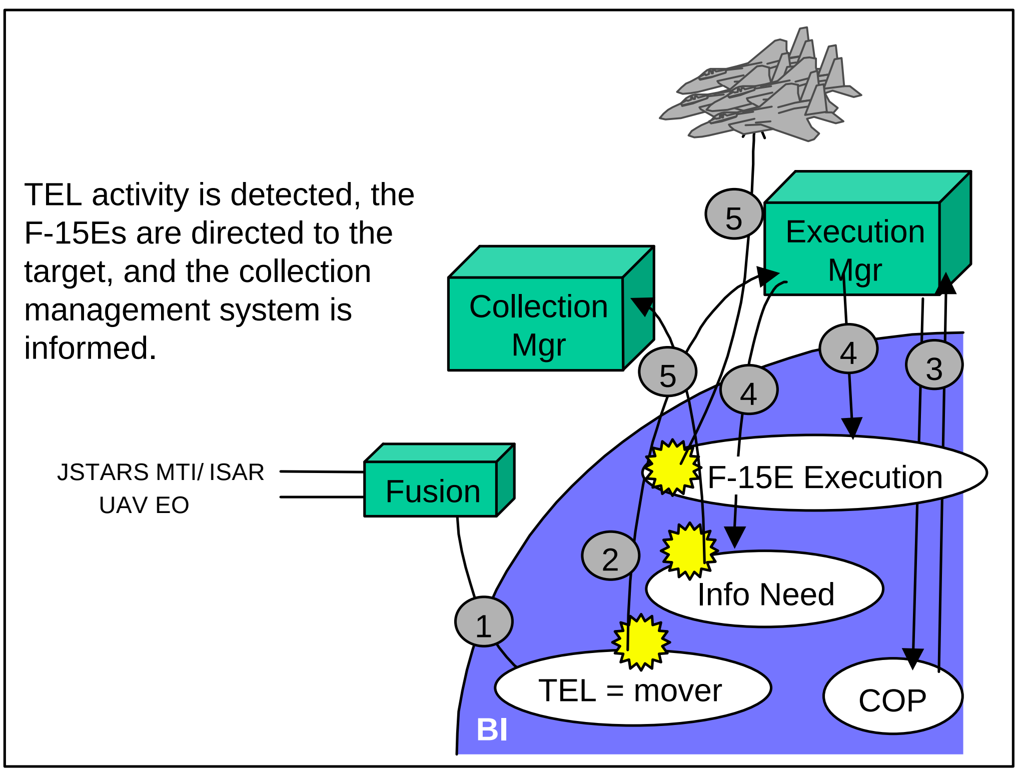

Figure 4-2. *Inside the BI During the First Operational Vignette Sequence*

4.1.2.1 Greater Detail for the First Technical Vignette Sequence

The actual information handling within the BI requires more than this level of processing. For this first vignette a second, more detailed description is offered. Figure 4-3 is used to support this discussion. JointSTARS detects a moving vehicle through ground moving-target indication (GMTI) and, by augmenting its MTI track with an inverse synthetic-aperture radar snapshot, determines that the vehicle is a Scud TEL while confirming it through a UAV EO snapshot. These sensor returns are fused in an exploitation/fusion system and entered as a fact (denoted "TEL = mover") in the common sit-rep.

1. This fact is subscribed to by a fuselet, which views the TEL as a potential target.
2. The fuselet queries the Air Tasking Order (ATO) to find aircraft with appropriate munitions loads that have not yet been assigned targets (or have been assigned to lower-priority targets). The BI ATO object responds with appropriately armed F-15Es.
3. The information that four F-15Es are available is passed to the execution manager.
4. The execution manager (based on either human permission or a rule-based process) selects these planes and checks the COP for known threats. It then computes a route to the target.
5. The execution order, including the route information, is published. The F-15E's subscription, used to pass the execution order to the aircraft, is not shown in the figure.
6. The information that planes are being sent to handle a particular target is subscribed to by another fuselet, which recognizes the need to publish a request for an ISR asset to track the TEL.
7. Current TEL status is an object in the BI, so a pointer to this information is added to the information request by the fuselet.

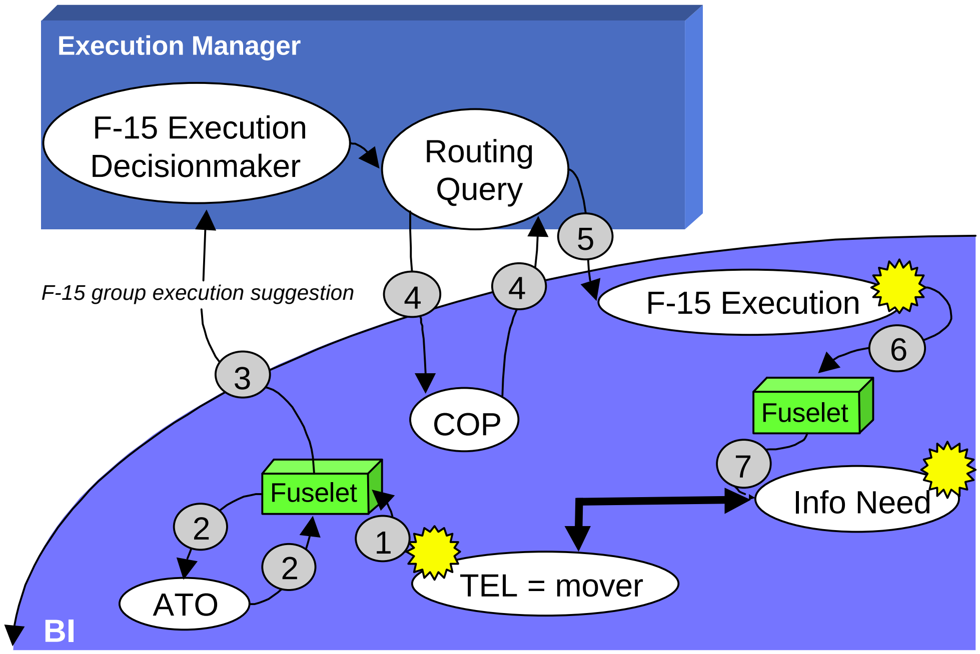

Figure 4-3. *Additional Detail of BI Processing of First Operational Vignette Sequence*

The remaining vignette sequences will provide only a higher-level description of BI processing.

4.1.3 Second Operational Vignette Sequence

While proceeding to their designated target, the F-15Es are picked up by a previously unknown SAM and are quickly targeted and fired on. Real-time threat warning is available from an electronic intelligence satellite to the F-15Es, fused onboard with their own threat warning systems. They take evasive action to avoid the SAM. Targeting information (in GPS coordinates) on the SAM site is provided to the F-15Es. The flight lead then makes a decision to send part of the flight to attack the SAM. While this is happening, the TEL changes from a mover to a sitter. JointSTARS switches to synthetic-aperture radar mode, focusing on the probable location of the TEL; a UAV EO sensor focuses on the same area. This is depicted in Figure 4-4.

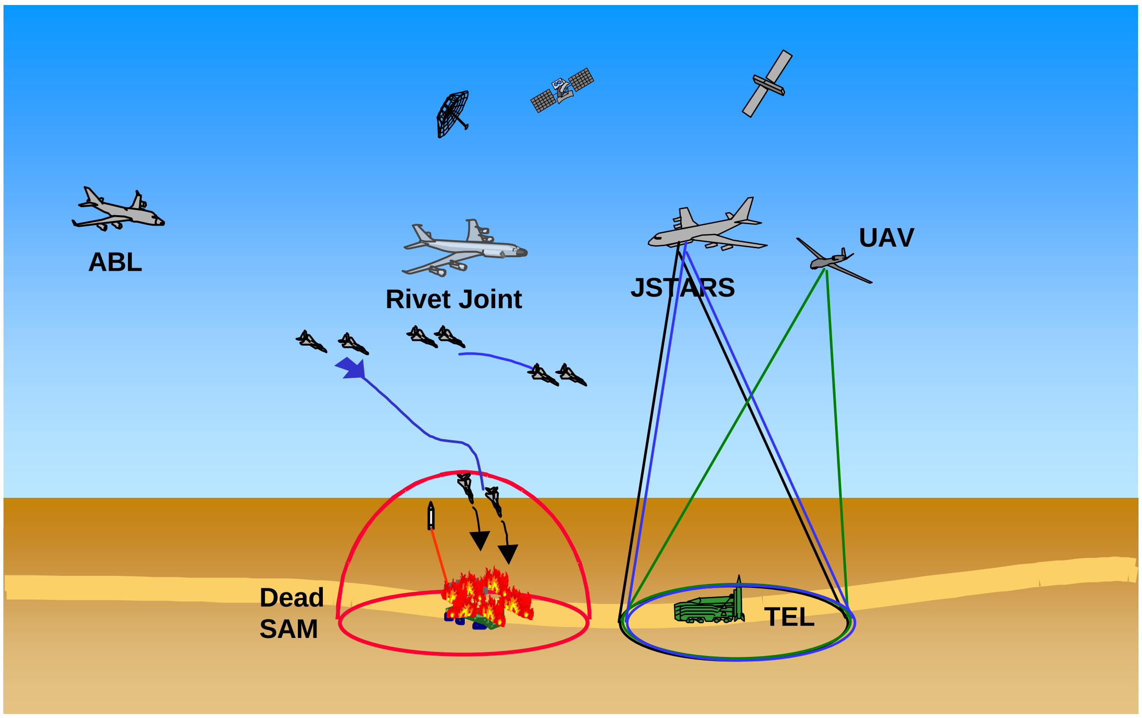

Figure 4-4. *Second Operational Vignette Sequence*

4.1.4 Second Technical Vignette Sequence

The processing occurring inside the BI during the second operational vignette sequence is depicted in Figure 4-5.

1. A pair of electronic intelligence sources provides a fused entry in the BI common situation representation that the SAM has been detected.
2. This triggers an instant message to the F-15Es that a SAM is present. The F-15Es' subscription catches information relating to the geospatial region of their planned flight, and the new information is passed immediately to the cockpit. They execute an instant defensive maneuver.
3. This defensive maneuver is automatically recorded in the BI, and the execution manager of the F-15Es is notified.
4. Meanwhile, the TEL becomes a sitter, a fact noted from the disappearance of GMTI returns.

5. The “TEL = sitter” entry in the BI triggers a notification to the collection manager to change the JointSTARS radar mode to synthetic-aperture radar (SAR) and to focus the SAR and a UAV EO sensor on the last position from the GMTI track.
6. The collection manager notifies the JointSTARS to change radar mode and the UAV EO sensor to focus on the last position from the GMTI track. The result of these efforts is that the “TEL = sitter” situation is confirmed. The JointSTARS and UAV sensor information is then recorded in the BI.

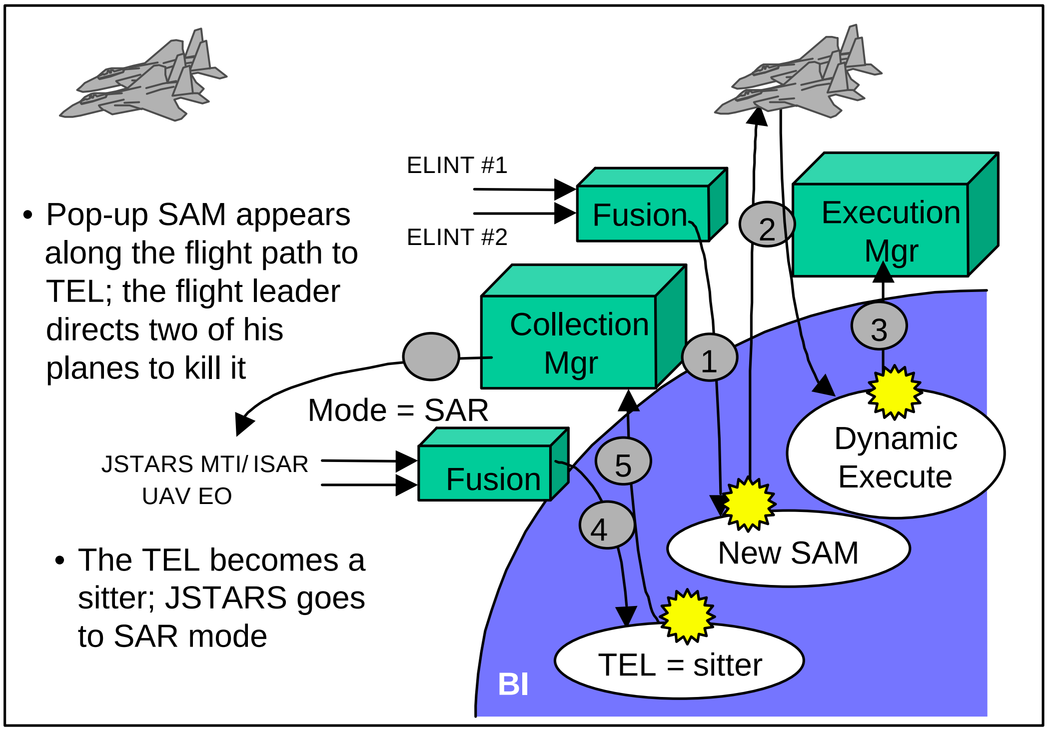

Figure 4-5. *Inside the BI During the Second Operational Vignette Sequence*

4.1.5 Third Operational Vignette Sequence

The third and final operational vignette is depicted in Figure 4-6. As the TEL becomes a sitter, it launches a Scud. The Scud is detected. The TEL then departs its launch position. These facts are noted in the BI, and an airborne laser shooter attacks the Scud, while the F-15Es attack the TEL.

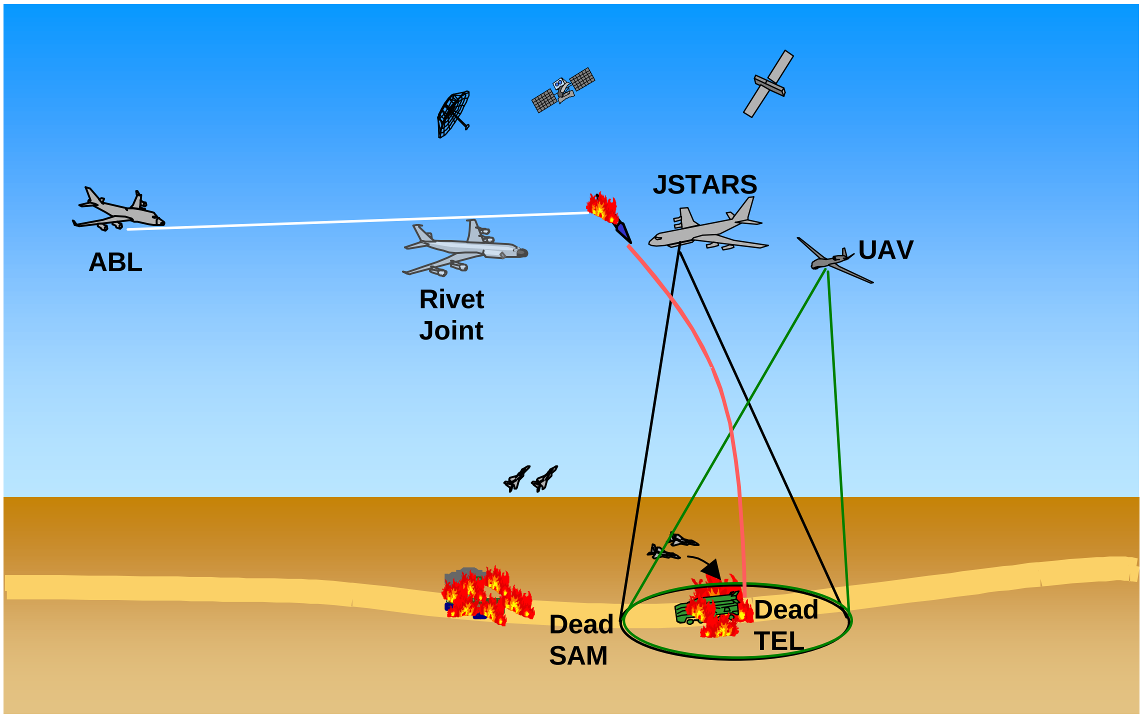

Figure 4-6. *Third Operational Vignette Sequence*

4.1.6 Third Technical Vignette Sequence

The processing occurring inside the BI during the third operational sequence is depicted in Figure 4-7.

1. The defense satellite program and the Airborne Warning and Control System detect the launch of the Scud. Their returns are fused and entered in the BI.
2. The launch triggers a notification to the nearby Airborne Laser (ABL). This fuselet subscribes to all TBM launch notifications. When it sees such a launch, it looks in the BI to see whether there is a likely TEL nearby (in this case, the "TEL = sitter" BI object). If so, it predicts that the TEL is likely to start moving. It automatically publishes this new information in the form of the "TEL = mover?" object so that ISR and/or other operational assets can be prepared.
3. The "TEL = mover?" entry in the BI triggers a notification to the JointSTARS and UAV to focus their assets on the area of the moving TEL. Their sensor modes shift back to GMTI. Simultaneously, the "TEL = mover?" entry in the BI triggers a notification to the execution manager to dynamically replan the F-15E missions to chase the TEL.
4. The replanned mission is entered into the BI.
5. This triggers a notification to the F-15Es to attack the TEL, which is destroyed, ending the scenario.

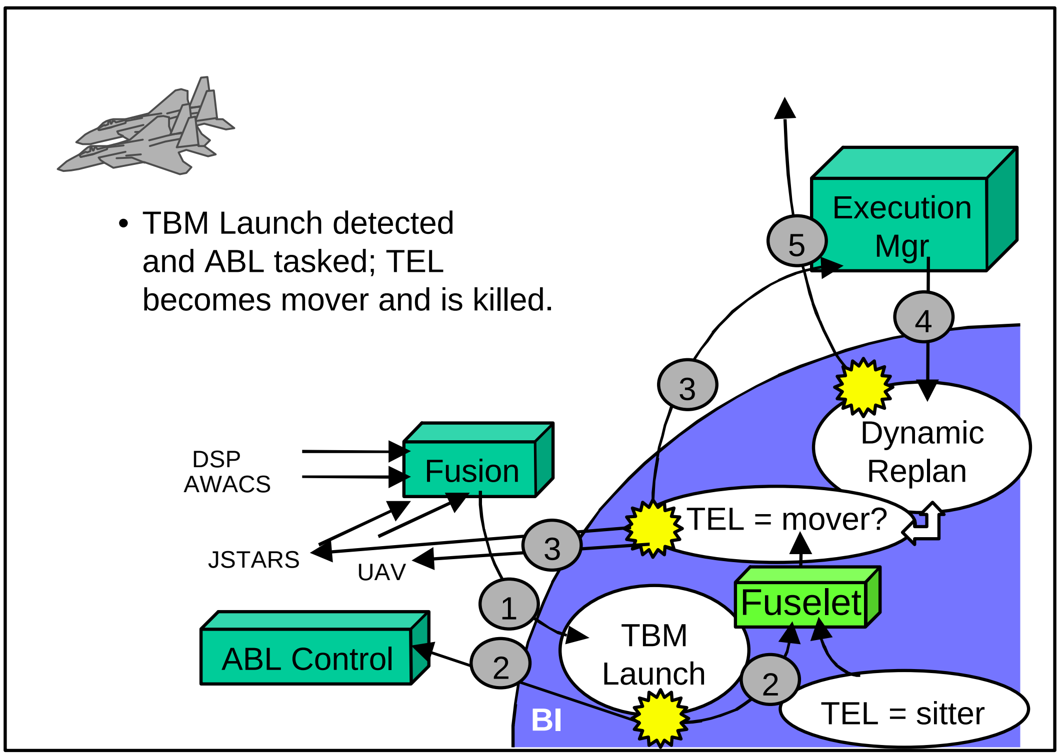

Figure 4-7. *Inside the BI During the Third Operational Vignette Sequence*

4.2 Benefits of the Battlespace InfoSphere

As demonstrated in the operational vignettes in this section, the BI provides an integrated support environment for the conduct of military operations. The next paragraphs highlight some of the key benefits derived from a BI.

4.2.1 Shared Information

The BI provides the capability to seamlessly share information among multiple functions and systems instantaneously. This reduces the duplication of effort required to retrieve and assemble information at all points of use.

4.2.2 Subscriptions Route Information

The use-driven dissemination of information ensures that it gets where it needs to go. As described in Chapter 3, geospatial tags, like the position information for the SAM and TEL in this chapter, identify information of interest to a theater of operations. High-priority information gets where it is going fast. The use of channels, as described in Chapter 3, ensures that low-priority information doesn't interfere with the delivery of high-priority information and allows for graceful degradation of the BI. Finally, subscriptions trigger real-time responses, allowing the ABL to destroy the launched missile early in its flight.

4.2.3 Automatic Transformation of Information

The combination and fusion of sensor data can produce information and reports for those who are interacting with the BI. For example, the combination of the TEL sitter identification and the TBM launch indication result in a new report indicating that the TEL will probably start moving.

4.2.4 Enables Rapid Decision Cycles

Automated processing and fusion of sensor information combined with an accurate, real-time view of the battlespace allows planners, commanders, and executors to access current situations and to respond as situations are developing.

4.2.5 Knowledge of Current and Planned Operations Is Widely Shared

Sharing of information permits decisionmakers at all echelons to make decisions in concert with the overall commander's intent. This helps avoid counterproductive decisions and permits enroute retargeting of weapon systems as battle damage is determined.

4.3 Summary

As demonstrated by the vignettes in this chapter, the BI will improve operational capabilities and change some of the processes currently used in conducting military operations. Implementation of such a system should be the goal of the Air Force, but there are some technological hurdles that must be overcome. The next chapter focuses on the technologies necessary to implement the BI and looks at their current and projected status.

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Chapter 5: Technologies

5.0 Technologies

IT has been both a boon to and the bane of the warrior. As a boon, IT provides access to information from almost anywhere in the world on virtually any topic of human experience at almost any time in history. It also enables warriors to manipulate data with greater accuracy and speed than any human who ever lived. The bane is that information can come flooding in to the warrior—in Desert Storm, for example, some personnel received 10,000 e-mails per day. Furthermore, the information is poorly organized, impossible to transport between systems, inconsistent in quality and accuracy, and seemingly without end. Since IT provides rapid answers, the warrior is unable to check the accuracy of the output. Recognizing these issues, the study panel undertook an extensive review of technologies that might be applied to support the IM needs of the warrior. The panel began with defining what information is, determining what requirements the BI places on technology, identifying key technologies that meet these requirements, and providing maturity and priority assessments. Each of these actions is reported in a separate section below.

5.1 Definitions

To identify technologies to support IM for the warrior, it was critical to define the following terms: *data*, *information*, *knowledge*, and *IM*. Definitions of the first three terms were adopted from an excellent review article by C. T. Meadow and W. Yuan (1997).[*] These authors derived the following general definitions from reviews of hundreds of research papers: “Data … a set of symbols with little or no meaning to the recipient. Information … a set of symbols that does have meaning or significance to their recipient. Knowledge … the accumulation and integration of information received and processed by a recipient.” The definition of IM was developed from requirements for the BI: IM is the input, manipulation, and access of information resources in order to plan and conduct missions. IM consists of processes and supporting technologies that enable the creation of a BI that presents a common knowledge environment to support operations—linking, sensing, deciding, and executing information resources anywhere, anytime. The technologies described in the subsequent pages are critical in enabling a BI in which information is accumulated, organized, disseminated, selected, and exploited in a timely, cost-effective manner from virtual, multilevel, and distributed information domains.

5.2 Matching Technology Requirements to the Battlespace InfoSphere

The BI has information input, manipulation, and interaction processes. These processes depend on underlying technologies that will enable information input directly from combat forces, which may supply that information as combat support products, fusion products from activities in the field, or planning activities, as well as execution events, directions from commanders, or end-user information related to each individual decisionmaker.

[*] Meadow, C. T., and W. Yuan. “Measuring the Impact of Information Defining the Concepts,” *Information Processing and Management*, Vol. 33, No. 6, 1997, pp. 697–714.

Manipulation processes depend on underlying technologies that support various levels of sophistication in the movement of information around the BI and the processing of the information within the BI. Capabilities to publish, subscribe, transform, query, and control information are provided by a variety of information technologies and by a variety of interactions among those technologies.

Interaction with the BI involves not only communication within the BI but also techniques for presenting information in ways such that the user can easily recognize the importance or consequence of information from the BI. Decision-centric presentation depends on preparation of information so that it is relevant to the decisions being contemplated. Automatic formatting and filtering of information provide ways to diminish extraneous information and make relevant information easy to understand. Task-centered information discovery will provide information interactions and information flows that can be predicted to be relevant to combat activities. Use-driven information dissemination will allow information interactions and information flows that were *unanticipated* at the outset of combat activities but become apparent as a consequence of the uses of information that take place. Interaction between users and the BI may take many sophisticated forms, but this last attribute—the ability to recognize the need for information interactions on the basis of use-driven events—will be one of the significant improvements to information manipulation in support of combat operations (see Figure 1-5).

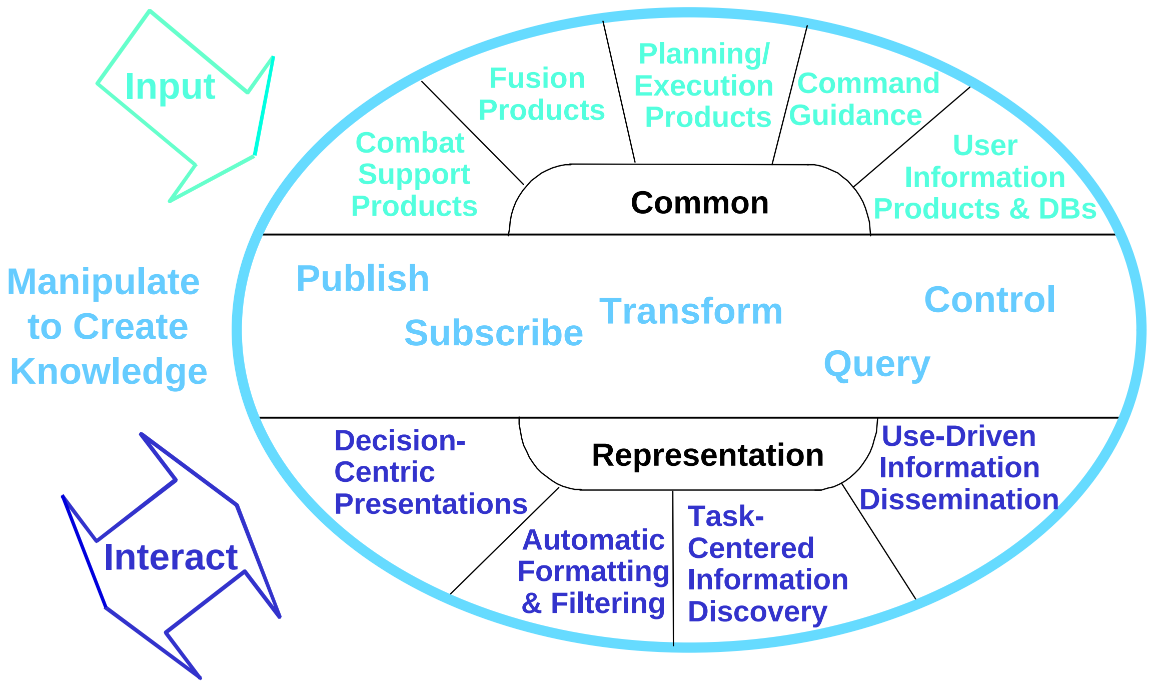

Figure 5-1. *Interacting With the BI*

5.2.1 Information Input

Information management processes enable the input of information, its manipulation, and subsequent interaction with the information. The processes and supporting technologies are described in Figures 5-2 through 5-4. In these figures, major technologies and associated

research and development (R&D) projects at agencies throughout the Government, academia, and industry were sorted according to a variety of prioritization schemes.

The technologies listed map to the functions that are embedded in the BI. Among the input technologies are identification and authentication, access and translation, upstream information, and categorization.

Identification and authentication are key to the ability to ensure that the support products and user-generated products come from sources that are reliable and properly labeled to indicate information pedigree. Similarly, identification and authentication are used to verify that commands and execution activities are provided by legitimate users and that interactions in the BI are conducted by people with the appropriate authority.

Access and translation technologies provide the capability to interface with existing (legacy) planning and execution systems, to translate information collected from the many input sources and transform it into a form suitable for manipulation throughout the BI, and to support the query processes necessary for fuselets and users to select information of interest.

Upstream information technologies also enable information to be tagged so that the path over which information flows is monitored and can be used to trace where information is sent after it enters the BI. The technologies also derive, from actions under way in the BI, the intent of users such that they are given information relevant to their intent. Source characterization and pedigree capture techniques are used to convey various assurance and confidence attributes on information so that reliance on information is matched to confidence in the information. These technologies will be used to tag and label information as it enters the BI as combat support products, fusion products, or products of planning, command, or user aggregated information.

Categorization allows information to be characterized relative to other information. Domain-specific taxonomies and ontologies establish a vernacular for describing relationships between different types of information. Relevance measures indicate the relative match between information content and the intent to which the information might be applied. Expectation-driven change-detection techniques can be used to assess whether the information being gathered is leading to a consistent state of awareness and to anticipate the arrival of new corroborating information.

These information input technologies are illustrated in Figure 5-2.

Candidate Technologies: Information Input

Identification & Authentication	Access & Translation	Upstream Information	Categorization
Source certificates	**Multimedia data capture**	**Tagging techniques**	**Domain-specific taxonomies & ontologies**
Secure ID	**Wrapper technology**	**Source characterization**	**Relevance measures**
Source availability	**Heterogeneous data integration**	**Capturing user intent**	**Expectation-driven change detection**
Source discovery	**Transformation techniques**	**Pedigree capture source processing**	
Source ID	**Capture plan data**		
	Meeting transcription		

Maturity of technology

Green—Ready to use, that is, commercial off-the-shelf or Government off-the-shelf (GOTS)
Blue—Commercial R&D under way; available in 5 years
Orange—Government R&D under way; available in 5 years
Red—No or insufficient R&D under way; needs programmatic support

Figure 5-2. *Candidate Technologies: Information Input*

5.2.2 Information Manipulation

Among the information manipulation technologies are storage, extraction, aggregation and fusion, accessing, decision support, labeling, and understanding.

Storage of information will be accomplished in a distributed environment and so technologies will be applied that enable information to reside in disparate locations yet be manipulated for many different processes. Among the various technologies that will be included in the storage environment are multimedia storage, resource distribution management, multilevel secure storage, and seamless access to tertiary storage. There is a significant amount of information and manipulation anticipated in the BI, so advances in high-performance computing, backup and recovery, mass storage, and data warehousing will be needed.

Extraction technologies will be necessary to adjudicate appropriate access restrictions and rules, to identify and preserve publication and subscription interests in the information, and to identify transformation opportunities based on information usage, user modeling, and intent inferencing. While transformation activities may use these technologies for internally recognized data extraction, query activities from the user or user's agent will also use these technologies. In the vignette described in Chapter 4, access control and collaboration sharing technologies enabled the execution manager and the aircraft to access the needed information to execute the mission.

Collaborative sharing technologies provided a method for the execution and fusion managers to take immediate action in tracking and finding the targets.

Aggregation and fusion technologies support the transformation, query, and control activities. Information of various forms needs to be fused, mediated, referenced, and compressed to derive better association between the underlying raw information and the decision support processes of the users. Information will be fused to prepare it for subsequent processing and evaluation in the BI.

The accessing technologies operate to enable manipulation of information across a wide variety of storage and network mechanisms—such as programming tools, scripting tools, testing, configuration control, debuggers, and CAD tools. The BI is expected to be implemented in a variety of physical forms wherein different computers at remote locations connected by a variety of network processes must interact with one another to constitute the BI.

Decision support technologies will enable control processes both in the manipulation of information and in the interaction processes that depend on the BI to recognize when decision activities relate to other information-manipulation processes.

Labeling enables the manipulation of uncertainty and domain interrelationships for information that needs to be fused, transformed, or otherwise made to interact with other information. The relationships among information with respect to the content, domain dependencies, and pedigree need to be managed during the fusion and aggregation, accessing, and decision support processing in the BI.

These information manipulation technologies are illustrated in Figure 5-3.

Candidate Technologies: Information Manipulation

Storage

- Multimedia storage
- Resource distribution management
- Multilevel secure storage
- Seamless access to tertiary storage
- High-performance computing
- Backup and recovery
- High-density mass storage
- Data warehousing

Extraction

- Access control
- Agent technologies
- Intelligent push technology
- Intent inferencing
- Dynamic access control
- Information usage
- Analysis
- User modeling

Decision Support

- Structuring
- Advice
- Uncertainty portrayal
- Tradeoff management

Aggregation & Fusion

- Video compression
- Wrapping legacy systems
- Information synchronization
- Geospatial & temporal indexing
- Object extraction for compression
- Metadata language
- Data fusion
- Information life cycle
- Database mediation
- Rapid knowledge formation

Accessing

- Collaboration technologies
- Self-healing networks
- Multilevel access
- Parallel access for speed

Labeling

- Uncertainty
- Domain-specific taxonomies & ontologies

Understanding

- Dynamic situation modeling
- Sensitivity

Maturity of technology

Green—Ready to use, that is, COTS or GOTS
Blue—Commercial R&D under way; available in 5 years
Orange—Government R&D under way; available in 5 years
Red—No or insufficient R&D under way; needs programmatic support

Figure 5-3. *Candidate Technologies: Information Manipulation*

5.2.3 Information Interaction Technologies

Among the information interaction technologies are routing, transmission, protection, communication, perception, user modeling, and collaboration.

The many forms of information storage and networked communications among the elements of the BI will require exploitation of modern Internet technologies; these will include a need for managing the limitations in communication bandwidth and doing so over a variety of communications channels.

Transmission technologies that measure and react to how information is flowing will be necessary to assure that critical information is exchanged, that accurate accounting of information is preserved, and that the ability to retrace the flow of information can be used for improving operations.

The dynamic nature of the BI requires that information be allowed to flow "freely" within the constraints of security and with mechanisms to retrieve information that was allowed to proceed in the interest of rapid response but that has subsequently been recognized as needing modification. Waiting for the information to be absolutely correct can inhibit the timely flow of information, but if there were no means of retrieving information subsequently found to be misleading, then waiting for correctness would be the only choice. With the ability to assuredly recover the consequences of prematurely released information, the advantages of anticipatory information dissemination can be exploited.

Communication of information needs to evolve into forms more friendly to human interaction. This will be particularly important for the rapid-fire interactions and decision processes anticipated as a consequence of applying the BI concepts. Communications technologies that enable the user to more effectively input instructions to the BI need to be applied.

Similarly, perception processes compatible with human interaction processes need to be developed. Visualization, nontraditional senses, tailoring to the user's mental model of the situation, and other information extraction technologies will need to be developed to maintain parity with the improved input and manipulation processes of the BI.

User modeling is anticipated as a means of enabling high-fidelity interaction between the user and the BI. As intent recognition emerges in the BI, the information manipulation processes may be better able to recognize the context of queries, the expectations of the user, and the means to most efficiently convey information from the BI to the decisionmaker.

Lastly, collaboration technologies that enable not only better interaction between the decision makers and the BI but also better interaction among decisionmakers are necessary. Advanced techniques for sharing information, issue-resolution strategies, and system support products will enable users to jointly recognize the interplay of operational decisions in a way that does not foster second guessing, but instead fosters better team coordination.

These information interaction technologies are illustrated in Figure 5-4.

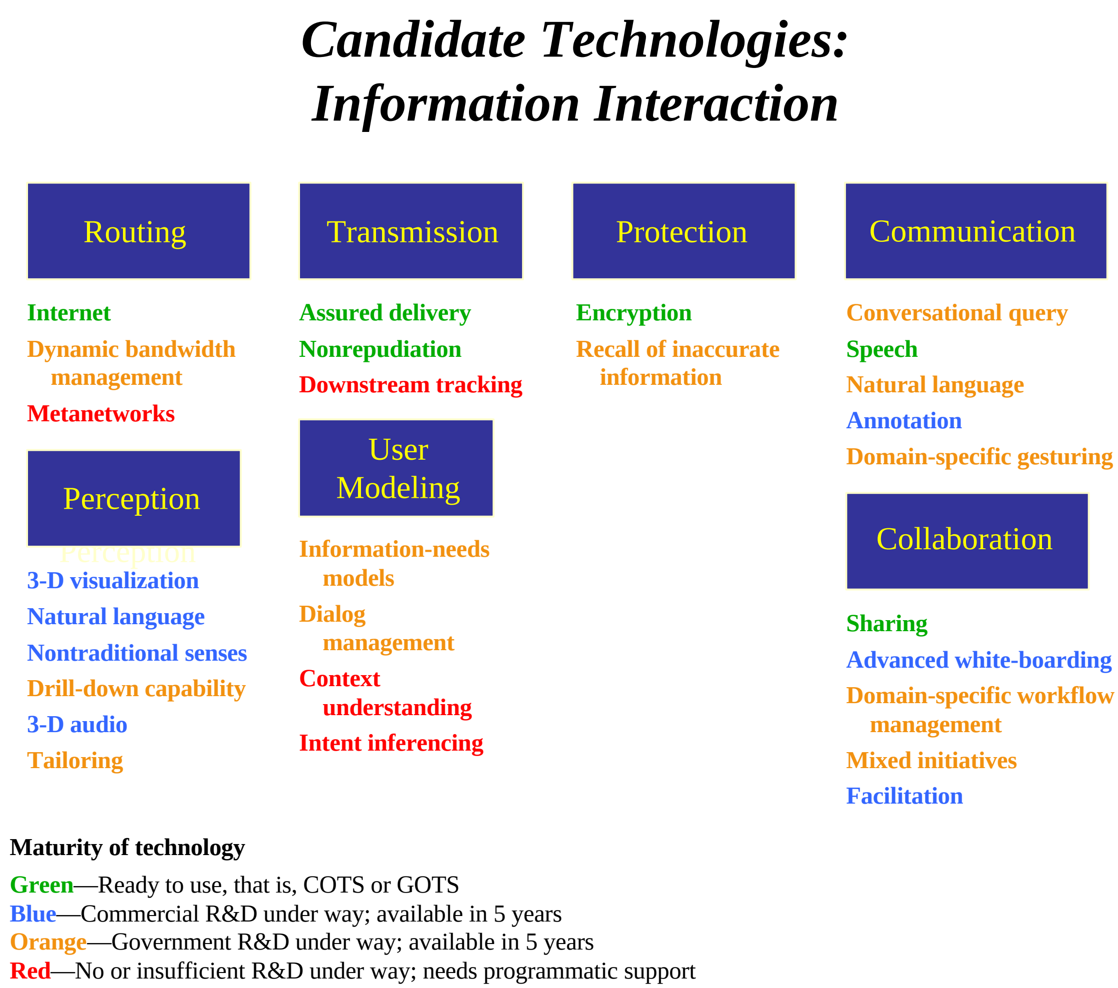

Figure 5-4. *Candidate Technologies: Information Interaction*

5.3 Key Enabling Technologies and Programs

The technology requirements imposed by the BI stem from the need to input, manipulate, and interact with information in an efficient, effective, and secure manner. These three goals can be met with nine enabling technologies that support the publication, subscription, query, control, transformation, and secure storage of information within the BI. Efficiency is enhanced by intent inferencing, wrapper technology, heterogeneous data integration, information life cycle, and geographical and temporal referencing; effectiveness by coordination technology and domain- and task-specific workflow management and visualization; and security by multilevel secure storage. Each of these nine enabling technologies is described in detail below.

5.3.1 Intent Inferencing

Intent inferencing is the ability of the system to infer what a user of the BI is trying to do. This is a crucial capability if the system is to do more than simply react to explicit commands. Like any good assistant, the system should also be able to deduce a user's goals and intentions and respond accordingly. This might include such actions as inferring that a user would be interested in some

information even though the user has not thought to ask for it. Intent inferencing will play a key role in enabling selective and intelligent publication of information (knowing what to publish and how to describe it) and in intelligent subscription management (as above, enabling distribution of information even to those who should have subscribed, but may not have).

5.3.2 Wrapper Technology

A considerable body of valuable information is currently inaccessible because it is stored in legacy databases not designed to interact with today's IM tools. *Wrapper technology* is the generic name for a variety of techniques designed to make this information transparently available to other systems. Wrapper technology is clearly going to be key in *publication* (getting information out of existing systems), *subscription* (knowing what kinds of information is available), and in *query* (getting the information out of the system and to the user).

5.3.3 Heterogeneous Data Integration

The profusion of databases in use and the lack of any standard way to categorize data means that a wide variety of ways to view the world have been built into diverse databases. Hence the user who tries to get information from more than a single database runs the risk that two sources mean slightly different things by the terms they use. *Heterogeneous data integration* refers to the ability to take information from two or more such sources and ensure that when the multiple sources are combined, the combination is sensible and coherent. This capability is fundamental to the *publication* and *query* capabilities of the BI.

5.3.4 Coordination Technology

Teamwork is not easy; teamwork for teams that are spread across time and space is even more difficult. *Coordination technology* refers to the set of capabilities that facilitate teamwork—simple capabilities, such as calendars and scheduling; more complex capabilities, such as multiple-author document creation; and sophisticated capabilities, such as multiperson planning. These technologies are key to the BI's ability to *control* its operation and to *transform* information in ways that users will find effective.

5.3.5 Domain- and Task-Specific Workflow Management

Coordination technologies offer a form of foundational support for the BI. But that set of technologies is not by itself sufficient. There are a variety of more specific procedures followed in a particular task (for example, integration of intelligence information, or air-space deconfliction planning), and to be effective the BI requires explicit representation and use of such procedures. Domain- and task-specific workflow management will provide key support for information *transformation* and *control* of BI processes.

5.3.6 Multilevel Secure Storage

As with all databases, the BI must tread a difficult line: it must make information available to those who need it and it must prevent information from being available to those who should not have it. A *multilevel secure storage* capability is central to the BI: there must be layering of information by security level so that wide dissemination is possible but so that tight control can

also be maintained for appropriate parts of the database. It is sufficiently key to the BI that all of its capabilities presume the existence of such a function.

5.3.7 The Information Life Cycle

All information will age; in the world of the battlespace it may age especially quickly, and the use of outdated information might be fatal. The BI will thus require an explicit model of and ability to enforce an information life cycle. It will need to know what information is newest and will need to have some idea of the "half-life" of a wide variety of information types. Maintaining an effective information life cycle is thus key to *publishing, transforming,* and *querying* the BI.

5.3.8 Geographical and Temporal Referencing

Perhaps the single most important information-organizing principle for the BI will be that of indexing information by geographical and temporal referencing. This too is sufficiently fundamental that it underlies all of the BI capabilities.

5.3.9 Visualization

Vast stores of information are of little utility if the user cannot understand what they are saying. Visualization technologies offer a variety of ways to present information so that the user can (quite literally) see what it says. Visualization will thus be central to the BI's ability to *transform* and *publish* information, and to its ability to reply to a *query* in a useful fashion.

As indicated in Chapter 3, the technologies needed to realize the BI can be organized in terms of three broad technologies: input, manipulation, and access. Within these 3, there are 18 narrower areas of technology. These 18 areas map to 83 specific technologies. Appendix D provides the panel's assessment of the state of the art in these 83 technologies.

5.3.10 Forming the Understanding of the Situation

It will be necessary to define a proper role for the fuselets that operate within the BI. In their current conception, these fuselets take as inputs only the contents of the BI, not contents of ancillary databases positioned outside the BI. Fuselets are envisioned as applets, which can be programmed by end users to output information to themselves or to selected other parties.

Fuselets can be constructed with a high-level scripting language that is accessible to end users of the BI. The mechanical details of their programming are not important to this discussion, but can be viewed as a "visual basic" for the BI end-user community.

What functionality should be provided by fuselets? Since their focus is "on-the-fly" integration of information, this discussion takes the position that they will be knowledge-level processors. Thus a useful attribute of the fuselets will be that they are an "easily used" version of a knowledge-based expert system. The integrating capability of the fuselets could then be derived from the invocation of rules to produce new knowledge within the BI.

In addition to a general-purpose reasoning engine, it may be useful to include a knowledge-based planning engine for fuselets. As distinct from "heavyweight" planners that lay outside the BI (ATO generators, for example), fuselet-based planners might assist end users in selecting broad-based courses of action using knowledge contained in the BI.

Five key BI elements might be employed in the operation of fuselets: (1) a blackboard that is implicit to the BI concept, (2) a powerful expert system engine that can be focused on a broad range of fuselet applications, (3) a simple end user programming facility, (4) the dynamic contents of the BI itself, and (5) knowledge-based planning functionality.

The precise form of an expert system engine appropriate to fuselets will require further thought. It may happen that the broad range of potential fuselet applications will benefit from the large-scale knowledge base work going on in the artificial intelligence community. A huge corpus of commonsense knowledge will be available online in the next few years, expressed in a form that can be used very effectively by fuselets.

Finally, great thought will be needed to understand the technical CONOPS for fuselets in conjunction with the heavyweight fusion and planning engines that are tangent to the BI and provide the river of data flowing into it. While it should be easy for end users to build fuselets, it should not be easy for them to dilute the quality of the COP, the ATO, and other key elements of the BI that are exposed to the global user community.

5.4 Method of Assessment

The method chosen for this assessment involved an e-mail survey of government agencies. A spreadsheet was created indicating the 3 broad technologies, 18 narrower technology areas, 83 specific technologies, and definitions of each specific technology. Agencies were asked to indicate R&D programs focused on these technologies, names of program managers, and Internet addresses for these individuals. They were also asked to indicate commercially available technologies that could meet the needs specified.

Surveys were e-mailed to 22 senior R&D managers in 14 different government agencies, including 11 DoD agencies, Federal Aviation Administration, National Aeronautics and Space Administration, and National Science Foundation. Responses were received from 10 agencies, and 11 completed spreadsheets for 8 agencies were received. These 11 compilations were merged, and duplicate programs were eliminated.

5.4.1 Database of Technology Programs

The resulting database, shown in Appendix D, includes 584 records linking ongoing R&D programs and the 83 specific technologies. This includes 207 programs or projects, with many programs or projects having more than one linkage.

Each database record includes the following 11 fields:

- Priority for Air Force investment
  1. Very high priority
  2. High priority
  3. Moderate priority
- Maturity of technology

  G (green)—Ready to use, that is, COTS or Government off-the-shelf (GOTS)

  B (blue)—Commercial R&D under way; available in 5 years

O (orange)—Government R&D under way; available in 5 years
R (red)—No R&D under way; needs programmatic support

- Readiness of technology to support BI
  1. Ready for initial BI
  2. Available for near-term BI
  3. Available for eventual full BI
- Technologies (three)
  1. Input
  2. Manipulate
  3. Access
- Area (18)
- Specific technologies (83)
- Definition/explanation
- Organization
- Research program
- Program manager's name
- Internet address

5.5 Technology Assessment

The primary question of interest in this study is the extent to which the technology requirements for the BI can be met by the 200-plus programs or projects and almost 600 linkages to technology needs captured in the database. There is a current average of seven ongoing R&D programs per technology need; 93 percent of technology needs are covered by two or more programs, and 64 percent of technology needs are covered by five or more programs. It is clear that overlapping programs must be coordinated and, where justified, combined. The major programs that seem to best support development of the BI are Command Post of the Future, Dynamic Database, and Joint Targeting Tool.

5.6 Summary

The assessment reported in Appendix D leads to a fairly straightforward conclusion. The technologies needed for the BI are, for the most part, being vigorously researched throughout government and industry. There are a few areas that warrant more investment (see the technologies with red maturity tags), and ongoing R&D programs are always vulnerable in the current funding climate. Nevertheless, the state of the art upon which the BI can be based is very rich indeed. To take advantage of this richness, investments in technology transfer and integration will be needed. Fortunately, however, these investments will be highly leveraged.

5.7 Recommendation

Rebalance Air Force information investments to achieve the Battlespace InfoSphere vision as soon as possible. There are many current efforts to build information systems, both in the Air Force and in DoD. These efforts lack the coherence that a BI would provide. The critical nature

of the BI suggests that the Services would be better served by rebalancing resources to move toward the BI goal. The panel recommends AF/XP tasking to address this item.

The technologies to support the BI are at various stages of maturity. The spiral development model allows for the evolution of a system from its initial capabilities. The acquisition plan should focus on both near-term and long-term BI technologies. With mature technologies, the Air Force should acquire the critical pieces of COTS that support a near-term BI. For less mature technologies, it should actively influence the evolution of COTS to meet BI needs and task USAF technical representatives to actively participate in commercial consortia.

Some of the technologies needed to support the BI are owned or being developed by the Government. The Air Force should acquire the critical pieces of GOTS that support a near-term BI. DARPA programs supporting both near- and long-term BI requirements include Dynamic Multi-user Information Fusion, JFACC, Adaptive Image Manager, and the Advanced Logistics Program. Other DoD programs should be identified and acquired. Existing DCE efforts should be directed toward definition of BI common object representations.

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Chapter 6: Implementing the Battlespace InfoSphere

6.0 Implementing the Battlespace InfoSphere

The creation of a BI requires a development plan similar to that for developing any other weapon system. The technologies discussed in the previous chapter must, in some cases, be developed, then integrated and tested to ensure proper functionality. An environment for such development, testing, and eventual fielding is already present in the Air Force organizational structure.

This chapter outlines a development approach and procurement discipline for achieving a BI. The Air Force spiral development model is proposed as the desired method of incrementally achieving a BI. Next a strategy for leveraging existing Air Force and DoD assets using this development model is proposed. Then current R&D efforts that can be used as a springboard for BI development are identified. Finally, a procurement discipline similar to that for other major weapon systems is proposed.

6.1 Battlespace InfoSphere Evolution

The evolution of the BI will involve concept evolution as well as technology evolution. Thus, a spiral approach to the development of the BI will be the most appropriate. Figure 6-1 shows that the evolution model starts with a set of applicable technologies plus an initial concept. The results of the initial experiments will create a revised concept and possibly a revised list of technologies. The challenge in using this spiral approach to concept and system evolution is to find the collection of mature technology that will support a meaningful test of the concept. If the spiral approach is done correctly, it will simultaneously change the way (information-centric) people think about and deal with information while accelerating the development and maturation of key technologies.

In Chapter 4, illustrative vignettes were presented as operational/technical pairs. The underlying technologies to achieve the vignettes might be introduced in an evolutionary manner as indicated in Figure 6-1. In Chapter 4, the appearance of TEL information activates triggers for execution managers to begin operation. In its primitive form, early instances of access control technology might be used to support profiling the needs of the various participants in the vignettes. Later instances of access control or collaborative technology might use more sophisticated trigger mechanisms to achieve improved associations of TEL information with execution manager actions. The spiral introduction of new technologies will lead to ever more sophisticated possibilities for the illustrated vignettes.

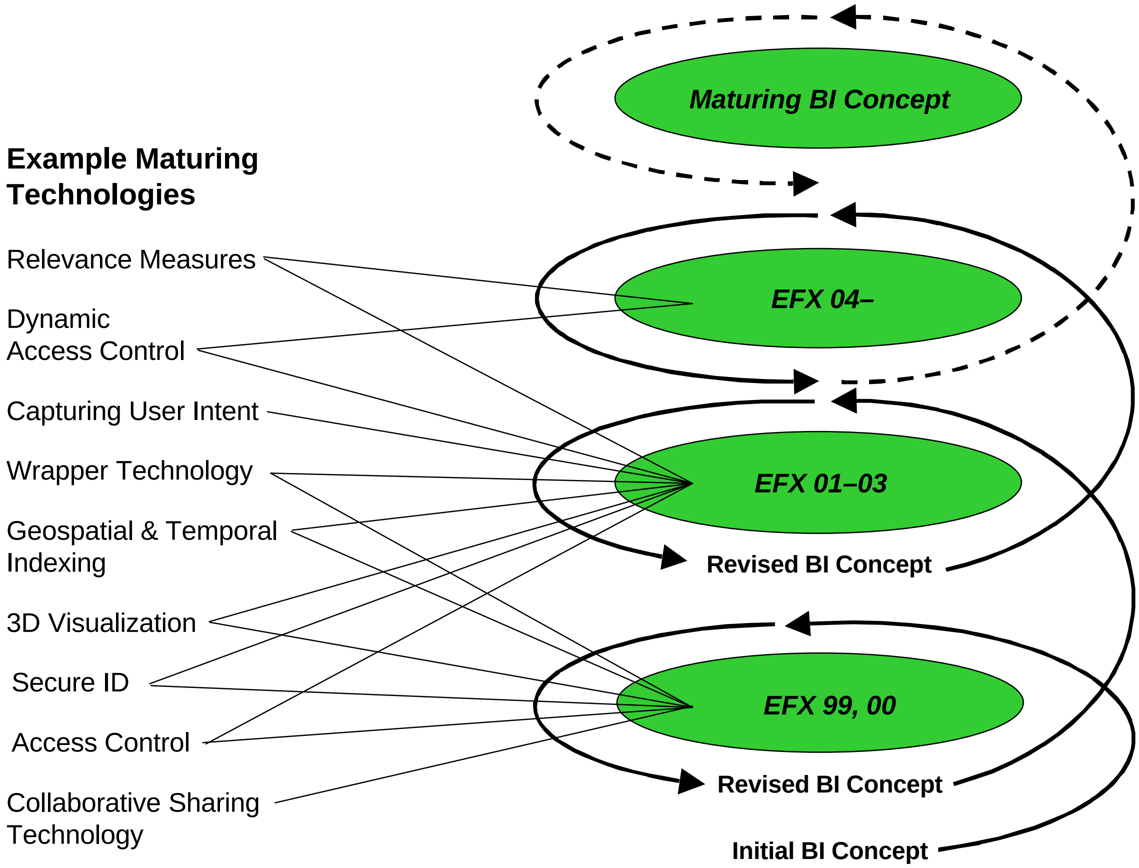

Figure 6-1. *BI Spiral Technology Evolution*

For each set of experiments, classes of technologies have been assigned, based on the predicted readiness of that class of technology. In addition, each set of experiments will have a theme associated with it, focusing on some collection of capabilities associated with the BI. These themes will provide an important focus to the operational capabilities being evaluated.

6.1.1 Initial BI (1999, 2000)

The main theme for the first set of experiments, targeted at Expeditionary Force Experiment (EFX) 99, EFX-00, will be the access and sharing of data. The technologies that are key to the access and sharing of data include

- Wrapper technology/heterogeneous data integration, which will provide standard ways to access and integrate a wide range of data sources/databases. This technology includes adding a layer on top of each data source to standardize key access functions as well as functions that combine data from the various sources.
- Geospatial and temporal indexing, which will allow the data to be accessed through a spatial or temporal reference.
- Visualization, which will probably be critical to supporting the users' understanding of the range of data they will access. Also, a key element of the visualization will be the ability of the user to refer to the needed data by interacting with the visualization.
- Secure ID, which is important for information assurance and protection.

- Access control, which will support initial publish-and-subscribe techniques for information management experimentation.

In addition to these key technologies supporting data access, current technology can also support data exchange among various systems. The adoption of sharing and white-boarding techniques to overlay existing systems demonstrated in EFX-98 as a capability that enables reachback operational concepts. It can also be used as a foundation for future development of the BI concepts.

6.1.2 Near-Term BI (2001–2003)

The main theme for the next cycle of experiments will be that of managing the information life cycle. Two key technologies in this area will be the information life cycle and domain-specific workflow management. The information life cycle technologies refer to a class of technologies for managing all aspects of the life cycle of a piece of information, from creation to destruction. As the extent of information that becomes integrated in the BI grows, the need for life-cycle maintenance becomes a critical function, both in terms of system performance and in terms of user support. In addition, the capability of sharing information will be achieved. Emerging data insertion, tagging, capturing user intent, object extraction for compression, etc., will support more sophisticated operational capabilities. Some lower-level capabilities will be integrated and the first forms of information subscription and fuselets will allow some types of information to managed according to the BI vision. Finally, it will be necessary to demonstrate the high-performance sensor-to-shooter linkages using publish-and-subscribe mechanisms.

6.1.3 Full BI (2004 and Beyond)

These sets of experiments will focus on raising the interaction to the knowledge and understanding level from the data and information level. This will be accomplished both through more elaborate functions for transforming data and information and through the ability to understand more of what the user needs. Two key classes of technologies that support better understanding of user needs are intent inferencing and collaboration technologies. Intent inferencing will provide the ability to more closely predict the user’s focus of attention by observing the user’s actions. The key idea is not to add more burden to the users by constantly asking them what they want, but instead to extract as much as possible through *a priori* knowledge of typical work processes and specific measurements of the users’ actions. Collaboration technologies will focus on intelligent support for user-to-user, user-to-system, and system-to-system collaborations. One objective for this set of experiments is to raise the presentation of information to the specific task level the user is working at, and to present it in such a way that the user can recognize the importance of it immediately, essentially changing it from a cognitive task to a perception task. The result must be that the command staff is equipped with the tools and training to create new fuselets and information flows to adapt to the evolving needs of a conflict.

6.2 The Road to Development

There are many possible roads to the development of the BI, some faster than others. The one the panel proposes takes advantage of existing organizations within the Air Force and DoD. The following proposals could significantly reduce the effort and time necessary to implement a BI.

6.2.1 Co-locate ESC and AC^{2}ISRC Assets at AOC–Rear

One means of accelerating the implementation of these concepts is to place a rapid prototype of the BI within easy access of future users (for example, Air Combat Command). This can be done by placing elements of ESC and the Aerospace Command and Control Intelligence, Surveillance and Reconnaissance Center (AC^{2}ISRC) in a single location with access to these users. Thus the panel suggests that the Langley AOC–Rear form the basis for an accelerated development process. Since components of the system will need to be provided by ESC, and since the full participation of the AC^{2}ISRC will be beneficial, both these organizations should provide assets at this proposed location. These two organizations should provide the core for development of a BI.

6.2.2 Leverage Jointness in the Tidewater Area

Clearly a project of this size and complexity must be integrated with the other Service and agency systems to be effective. Therefore a joint development approach is not only desirable but a necessity. By leveraging the momentum toward joint systems within the Tidewater area, it should be possible to expand the Air Force thought process to include joint requirements. The location of other DoD assets in the area will facilitate cooperation among the Services.

6.2.3 Consider BI for a Billy Mitchell Initiative

The size and scope of the BI will entail a significant level of effort. The Air Force battlelabs have various project levels indicating the amount of effort necessary. The panel proposes that this activity be elevated to be a Billy Mitchell battle lab initiative.

6.2.4 Exploit the New ESC Spiral Acquisition Model

Finally, the panel proposes that the new ESC acquisition model described in section 6.2 form the basis for the development process.

The initial development process and timeline are shown in Figure 6-2. Based on the discussion in this section, ESC and AC^{2}ISRC should form the core of the development effort. The first spiral of development is represented without including the joint organizations that may contribute to the initial operational capability.

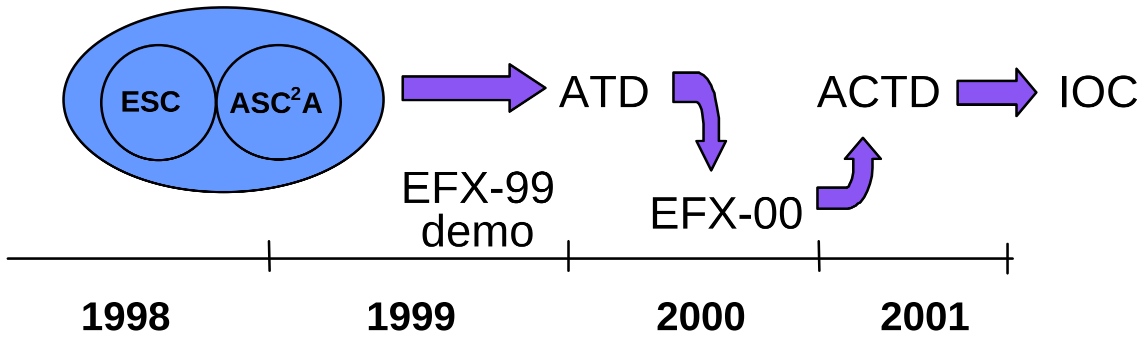

Figure 6-2. *BI Acquisition Strategy*

6.3 Elements of the Proposed Development Process

The path toward an object-based BI will be shortened substantially if the initiatives of DARPA and other organizations are used as a starting point. The panel recommends rapid prototyping of portions of the BI to educate potential Air Force users of the system and to address some of the issues raised in Section 3.3. As with many information systems, it is easiest to learn from the real system. The existing Air Force structure for rapid development and testing is summarized in Figure 6-3.

- Elements of an Air Force–sponsored ATD include:
  - Combat applications that can publish objects following the object definition
  - An initial definition of combat information objects, together with services for publishing, subscribing, querying, transformation, and control
  - Initial tools to permit interaction with the BI information
- Major object-oriented applications can be obtained from DARPA and other sources; applications include fusion (Dynamic Multi-user Information Fusion), collection management (Adaptive Image Manager), planning (JFACC), combat support (Advanced Logistics Program), global information exchange, and information dissemination management
- The Air Force needs to do the detailed engineering for combat information objects and BI services
- An ACTD with leave-behind assets would follow

Figure 6-3. *Strategy for ATD/ACTD*

The core elements of an Air Force initiative in this area include an initial portfolio of object-based combat applications, a coherent definition of Air Force objects to be used as design guidelines, and an initial toolkit that permits interaction with the BI.

Many of the 6.2 and 6.3 software systems in development at DARPA and other agencies are object-based and can be used directly. Included in these are DARPA fusion programs such as Dynamic Multi-user Information Fusion and Dynamic Database, collection management (Adaptive Image Manager), and ATO generation (JFACC). Programs such as global information exchange and information dissemination management from other government organizations are relevant.

It is important to realize the fungible nature of Air Force Research Programs (6.2 and 6.3 programs) as well as commercial standards when making provision for their import into Air Force long-term strategies. Reorganization of programs such as JFACC or their sponsoring agencies can cause disruption of Air Force plans, since they are driven by issues other than those of the Air Force itself. Any of the programs mentioned above could suffer from redirection or curtailment. It is

important that the Air Force maintain its own balance through such course changes and provide long-term focus to capabilities it considers important.

Along these lines, there are areas where the Air Force must ensure stability and focus, including the detailed engineering of certain key components of the BI (for example, the detailed design of the information objects required to support the Air Force's missions). Functionally key components of the design should be identified early, and programs set in place to ensure their availability.

With a proper substrate put in place at AOC–Rear, an ACTD or other exercise should be sponsored that will leave assets behind for long-term evaluation.

6.4 Procurement Discipline

Construction of the BI is best served by moving the software and BI system development process toward more disciplined forms. Since the 1940s, software development has focused on megalithic applications, and in recent years on the sequential "waterfall" method and other approaches that attempt to focus on scheduled development time.

The major warfighting systems of the Air Force such as the F-22 are constructed with a clear component-based architecture of systems and subsystems, with careful integration, and with evolutionary progress through block upgrades. This entire process has been used for many years to achieve a formidable portfolio of Air Force platforms.

The suggestion is to turn this same thoughtful approach on the BI itself. Base its development on the idea of functionally defined components, assembled in the same manner as aircraft subsystems. The components of an object-based software system should be directly identified with elements of the warfighter's universe (threats, Blue forces, plans, etc.). Figure 6-4 compares the process of developing a major weapon system like the F-22 with the process of developing a BI.

Characteristics	***F-22A***	***BI-1A***
Management discipline	X	X
Subsystems	X	X
Systems integration	X	X
Operator certification	X	X
Logistics support	X	X
Block upgrades	X	X

Apply similar cost-performance evaluation methods

Figure 6-4. *Use Integrated Development Processes for the BI*

Using a familiar approach eases the dialog between the BI designers and the warfighter during the design process. This simplification of dialog reduces the chance for error in the final product and eliminates potential gaps in the military processes that the BI must support. It also facilitates change, since evolution of the system entails replacement of functionally defined components, rather than entire applications. Finally, provision for cost/performance evaluation is enhanced, since snapping alternate components in and out of the system leads to simpler considerations during tradeoff analysis.

6.5 Summary

This chapter proposes an approach that allows for the evolution from current systems through a full BI. The ESC spiral development model is outlined as the best alternative for achieving an initial capability that can then be expanded into the BI as envisioned. It is then proposed that this development be spearheaded by ESC and AC^{2}ISRC assets located at the AOC–Rear at Langley and involve cooperation from across DoD and with other government agencies. Finally, a procurement discipline similar to that for other weapon systems is proposed as a realistic goal for minimizing development time and problems.

To meet the aggressive timeline proposed in this chapter, the next chapter offers specific recommendations for achieving the goal of implementing a BI.

6.6 Recommendations

Integrate combat information resources to provide a single integrated structure and a single responsible organization. To be effective, information must be available to the people and systems

that need it. Integration is the key to making this possible by making sure that information can be communicated. With so many systems involved, integration by committee will not work. There must be a single organization responsible for achieving the Air Force vision. The panel recommends AF/XO tasking to address this item.

Adopt the discipline of a major weapon system program with the speed of spiral development. Like other major systems, an organized development and maintenance approach can reduce procurement time and allow for the evolution of the system as new technologies and processes become available. The panel recommends AF/AQ tasking to address this item.

Seek Air Force leadership but ensure joint development of the Battlespace InfoSphere. The nature of the BI ensures that no Service can go it alone in BI development. Increased reliance on joint and coalition operations means that the effectiveness of the BI will be limited by the capabilities of the participants. The unique characteristics of aerospace assets suggests that the Air Force should take the lead in developing the BI in cooperation with the other Services. The panel recommends AF/XO tasking to address this item.

The Air Force Chief of Staff should initiate and fund a program to develop a BI. To this end, the Air Force Materiel Command should be tasked to take the lead (ESC program management) and the AC^2ISRC and C^2 battle lab should be tasked to refine requirements and the concept of operations. The Air Force should sponsor an accelerated Advanced Technology Demonstration (ATD) followed by an ACTD demonstrating an integrated BI. To ensure the existence of the necessary technology base for the BI, Air Force Office of Scientific Research and the Air Force Research Laboratory (AFRL) should begin initiatives on critical technology.

The Air Force should seek DoD assistance for BI development. It should evaluate the wider use of the BI in a joint-Service environment. Assistant Secretary of Defense (C^4I) should conduct a policy review and coordinate with DoD architecture initiatives. In addition, DoD agency (Defense Information Systems Agency, Defense Advanced Research Projects Agency, National Reconnaissance Office, etc.) support should be sought. Finally, due to the nature and types of information required to populate the BI, the Air Force should ask the Director of Central Intelligence to provide CMS assistance for intelligence integration.

Chapter 7: Recommendations

7.0 Recommendations

The BI is a necessary and achievable extension of the information systems of today. As the revolution in military affairs continues to gather speed, the Air Force will find its combat operations ever more tightly bound to IM. The Air Force is already proceeding down this path with current-day megalithic systems for ATO generation, air transport planning, exploitation, and other applications. These systems, although very important for current operations, will not meet the needs of the future Air Force for rapid asynchronous global operations. It is, therefore, critical that a better way to manage information be developed.

The Air Force has challenging requirements for IM. These include:

- Global support for mobile air/space/ground systems. For example, airborne B-2s must be linked to ground-based C^2 systems half a world away.
- Integrated functionality for C^2 systems. For example, future real-time execution managers require interoperation between controller decision support software, ISR management systems, and shooter avionics.

As a result of these and other requirements and the need to leverage assets to the maximum extent possible, the Air Force should take the lead in achieving a BI. The next section presents a set of recommendations for realizing this requirement.

7.1 Specific Recommendations

7.1.1 Approve and Adopt the Battlespace InfoSphere as an Air Force Vision

This vision will provide a common goal for integrating disparate systems into an information-rich environment that enhances operational capabilities and combat effectiveness. This activity needs to occur at the Chief of Staff level.

7.1.2 Integrate Combat Information Resources to Provide a Single Integrated Structure and a Single Responsible Organization

To be effective, information must be available to the people and systems that need it. Integration is the key to making this possible by making sure that information can be communicated. With so many systems involved, integration by committee will not work. There must be a single organization responsible for achieving the Air Force vision. AF/XO tasking is recommended to address this item.

7.1.3 Adopt the Discipline of a Major Weapon System Program With the Speed of Spiral Development

Like other major systems, an organized development and maintenance approach can reduce procurement time and allow for the evolution of the system as new technologies and processes become available. AF/AQ tasking is recommended to address this item.

7.1.4 Rebalance Air Force Information Investments to Achieve the Battlespace InfoSphere Vision as Soon as Possible

There are many current efforts to build information systems, both in the Air Force and in DoD. These efforts lack the coherence that a BI would provide. The critical nature of the BI suggests that the Services would be better served by rebalancing resources to move toward the BI goal. AF/XP tasking is recommended to address this item.

The technologies to support the BI are at various stages of maturity. The spiral development model allows for the evolution of a system from its initial capabilities. The acquisition plan should focus on both near-term and long-term BI technologies. With mature technologies, the Air Force should acquire the critical pieces of COTS that support a near-term BI. For less mature technologies, it should actively influence the evolution of COTS to meet BI needs and task U.S. Air Force technical representatives to actively participate in commercial consortia.

Some of the technologies needed to support the BI are owned or being developed by the Government. The Air Force should acquire the critical pieces of GOTS that support a near-term BI. DARPA programs supporting both near- and long-term BI requirements include Dynamic Multi-user Information Fusion, JFACC, AIM, the Advanced Logistics Program, Information Management, and Intelligent Collaboration and Visualization. Other DoD programs should be identified and acquired. Existing DCE efforts should be directed toward definition of BI common object representations.

7.1.5 Seek Air Force Leadership but Ensure Joint Development of the Battlespace InfoSphere

The nature of the BI ensures that no Service can go it alone in BI development. Increased reliance on joint and coalition operations means that the effectiveness of the BI will be limited by the capabilities of the participants. The unique characteristics of aerospace assets suggests that the Air Force should take the lead in developing the BI in cooperation with the other Services. AF/XO tasking is recommended to address this item.

The Air Force Chief of Staff should initiate and fund a program to develop a BI. To this end, the Air Force Materiel Command should be tasked to take the lead (ESC program management) and the AC^{2}ISRC and C^2 battle lab should be tasked to refine requirements and the concept of operations. The Air Force should sponsor an accelerated ATD followed by an ACTD demonstrating an integrated BI. To ensure the existence of the necessary technology base for the BI, Air Force Office of Scientific Research and the Air Force Research Laboratory should begin initiatives on critical technology.

The Air Force should seek DoD assistance for BI development. It should evaluate the wider use of the BI in a joint-Service environment. Assistant Secretary of Defense (C^{4}I) should conduct a policy review and coordinate with DoD architecture initiatives. In addition, DoD agency (Defense Information Systems Agency, Defense Advanced Research Projects Agency, National Reconnaissance Office, etc.) support should be sought. Finally, due to the nature and types of information required to populate the BI, the Air Force should ask the Director of Central Intelligence to provide CMS assistance for intelligence integration.

7.2 Summary

The recommendations contained in this section provide a starting point for development and fielding of a BI. Information has always been a critical element in warfare. Invariably, the side with the best information resources is more efficient and effective in applying its resources. The time is here for the BI as a concept, but the technology and policy are lagging. The Air Force should take the necessary steps to make the BI a goal and to achieve that goal.

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Acronyms and Abbreviations

ABIS	Advanced Battlespace Information System
ABL	airborne laser
AC^2A	Aerospace Command and Control Agency (formerly the Air and Space Command and Control Agency; now the Command and Control Intelligence, Surveillance, and Reconnaissance Center)
AC^2ISRC	Aerospace Command and Control Intelligence, Surveillance, and Reconnaissance Center
ACTD	Advanced Concept Technology Demonstration
AEF	Aerospace Expeditionary Force
AF	Air Force
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AIM	Adaptive Image Manager
ALP	Advanced Logistics Program
AOR	area of responsibility
APORTS	aerial ports
ASC^2A	Air and Space Command and Control Agency (later the Aerospace Command and Control Agency; now the Command and Control Intelligence, Surveillance, and Reconnaissance Center)
ASTOR	Airborne Stand-Off Radar
ATO	air tasking order
AWE	Advanced Warfighting Experiment
BDA	battle damage assessment
BI	Battlespace InfoSphere
C^2	command and control
C^4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CDE	Common Data Environment
CEC	Cooperative Engagement Capability
CINC	Commander in Chief
CM	cruise missile
COE	common operational environment
COMINT	communications intelligence
CONOPS	concept of operations

CONUS	continental United States
COP	common operating picture
COTS	commercial off-the-shelf
DARPA	Defense Advanced Research Projects Agency
DCI	Director of Central Intelligence
DDR&E	Director, Defense Research and Engineering
DII	Defense Information Infrastructure
DISA	Defense Information Systems Agency
DMIF	Dynamic Multi-user Information Fusion
DoD	Department of Defense
DSB	Defense Science Board
DSP	Defense Support Program
ELINT	electronic intelligence
EO	electro-optical
FAA	Federal Aviation Administration
GCCS	Global Command and Control System
GOTS	Government off-the-shelf
HUMINT	human intelligence
IM	information management
IS	information superiority
ISR	intelligence, surveillance, and reconnaissance
IT	information technology
JCS	Joint Chiefs of Staff
JFACC	Joint Forces Air Component Commander
JointSTARS	Joint Surveillance, Target, and Attack Radar System
JTF	Joint Task Force
JTS	Joint Technical Architecture
JV 2010	Joint Vision 2010
KQML	knowledge query manipulation language
MLS	multilevel security
MRC	Major Regional Conflict
MTI	moving-target indicator
NASA	National Aeronautics and Space Administration
NCW	network-centric warfare
NIMA	National Imagery and Mapping Agency

NIST	National Institute of Science and Technology
NRO	National Reconnaissance Office
NSA	National Security Agency
NSF	National Science Foundation
OSD	Office of the Secretary of Defense
PDA	personal digital assistant
R&D	research and development
SAB	Scientific Advisory Board
SAM	surface-to-air missile
SIG SEC	signals security
SQL	Structured Query Language
TBM	theater ballistic missile
TBMCS	Theater Battle Management Core System
TEL	transporter-erector-launcher
UAV	unmanned aerospace vehicle
URL	uniform resource locator
USAF	United States Air Force

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Appendix A: Terms of Reference

USAF Scientific Advisory Board

1998 Ad Hoc Study on

Information Management to Support the Warrior

Terms of Reference

January 1998

BACKGROUND: Previous SAB studies have identified the need to increase communications bandwidth and develop information support systems to enhance Air Force combat and combat support capability. The Air Force has made significant progress in providing information tools to support the planning and operations requirements derived from the Desert Storm experience. The initial response was the design of a pull system that would permit the user to pull necessary information from databases maintained by a variety of organizations. The overwhelming amount of information available and the time necessary to locate it led to the development of anchor desks to help manage information requests. Anchor desks soon learned that the information needs of the users were sometimes the same and then bundled information to push it to the users, anticipating their needs. This push-pull system is about where the Air Force stands today. A consequence is that trillions of information bytes are falling on the floor as the users find themselves overwhelmed with the data available and unable to sort through it to find exactly what they need.

The Air Force needs to develop IM concepts that permit users at every level and every function to define their information requirements dynamically to accommodate changing phases of the mission. Commanders at every echelon need a variety of data available in real time. Displays of the data need to accommodate numerous inputs simultaneously with tools to help prioritize and cue the individual to needed decisions. The human interface factors, software engineering and communication interfaces are all interrelated in meeting the warrior's needs. New IM technology and concepts being developed in the commercial world may provide enhanced information tools for the warfighter.

STUDY PRODUCTS: Briefing to SAF/OS & AF/CC in Oct 1998. Report completion by Dec 1998.

STUDY CHARTER: The goal of the study is to review the current AF, DARPA, DISA and other Services programs in IT as well as commercial and defense contractors' new approaches and identify one or more approaches to the IM problem already underway in various DoD organizations and in the commercial world. Technology advances will permit continuous improvement in this area over time. However, today there is a need for the decision-maker to select one or more approaches and this study should provide a sufficient knowledge base to select the correct approaches at this time.

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Appendix B: Members and Affiliations

Study Chairman: General James McCarthy, USAF, Ret
Olin Professor of National Security, U.S. Air Force Academy

General Officer Participant: Maj Gen John Hawley
Commander, Aerospace Command and Control Agency

Study Panel Members	**Affiliation**
Dr. Randall Davis	MIT
Prof. Edward Feigenbaum	Stanford University
Dr. Valerie Gawron	Calspan, an operation of Viridian
Prof. Randy Katz	University of California, Berkeley
Dr. Barry Leiner	Corporation for National Research Initiatives
Dr. Charles Morefield	Alphatech
Dr. William Rouse	Enterprise Support Systems
Dr. Robert Sproull	Sun Microsystems
Maj Gen Thomas Swalm, USAF, Ret	Consultant
Mr. Scott Fouse	ISX
Prof. James Hendler	University of Maryland
Mr. Edward Mahen	SRI
Maj Gen Richard O'Lear, USAF, Ret	Oracle/Lockheed Martin
Mr. Thomas Saunders	Mitre
Mr. George Spix	Microsoft
Mr. Bernhard Hoenle (Government Advisor)	AFCIC/IT
Executive Officer: Maj Douglas Amon	AF/SB
Tech Writer: Maj Mark Huson	USAF Academy

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Appendix C: Committee Meetings

Kickoff Meeting
28–29 January 1998
Washington, DC: ANSER and DARPA

Information Gathering Meeting
17–18 February 1998
Boston, MA: ESC and MIT

Information Gathering Meeting
16–17 March 1998
Hurlburt Field, FL: C^2 Training and Information Center
Eglin AFB, FL: UAV Battlelab

Information Gathering Meeting
1 April 1998
New York, NY: Andersen Consulting, Bloomberg

SAB Spring Board
23–24 April 1998
Colorado Springs, CO: Space Command

Collaborative Visualization Information Management Demonstrations
14 May 1998
San Diego, CA: SPAWAR Systems Center–San Diego

Information Gathering Meeting
18–19 May 1998
Berkeley, CA: University of California, Berkeley
Stanford, CA: Stanford University
San Mateo, CA: Inktomi Inc.
Redwood Shores, CA: Oracle
Palo Alto, CA: Xerox PARC
Palo Alto, CA: Teknowledge

Information Gathering Meeting
28–29 May 1998
San Diego, CA: SPAWAR Systems Center

Information Gathering Meeting
8–9 June 1998
Rome, NY: AFRL Information Technology Directorate

SAB Summer Study
15–26 June 1998
Irvine, CA

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Appendix D: Information Management Technologies

As indicated in Chapter 3, three broad technologies are needed to realize the BI: input, manipulation, and access; within these three, there are 18 narrower areas of technology. These 18 areas map to 83 specific technologies. This appendix focuses on assessing the state of the art in these 83 technologies.

The method chosen for this assessment involved an e-mail survey of government agencies. A spreadsheet was created indicating the 3 broad technologies, 18 narrower technology areas, 83 specific technologies, and definitions of each specific technology. Agencies were asked to indicate R&D programs focused on these technologies, names of program managers, and Internet addresses for these individuals. They were also asked to indicate commercially available technologies that could meet the needs specified.

Surveys were e-mailed to 22 senior R&D managers in 14 different government agencies, including 11 DoD agencies, FAA, NASA, and NSF. Responses were received from 10 agencies, and 11 completed spreadsheets for 8 agencies were received. These 11 compilations were merged, and duplicate programs were eliminated.

The resulting database includes 584 records linking ongoing R&D programs and the 83 specific technologies. This includes 207 programs or projects, with many programs or projects having more than one linkage.

Each database record includes the following 11 fields:

- Priority for Air Force investment
  1. Very high priority
  2. High priority
  3. Moderate priority
- Maturity of technology
  G (green)—Ready to use, that is, COTS or Government off-the-shelf (GOTS)
  B (blue)—Commercial R&D under way; available in 5 years
  O (orange)—Government R&D under way; available in 5 years
  R (red)—No R&D under way; needs programmatic support
- Readiness of technology to support BI
  1. Ready for initial BI
  2. Available for near-term BI
  3. Available for eventual full BI
- Technology areas (three)
  1. Input
  2. Manipulate
  3. Access
- Area (18)
- Specific technologies (83)

- Definition/explanation
- Organization
- Research program
- Program manager’s name
- Internet address

The primary question of interest in this study is the extent to which the technology requirements for the BI can be met by the 200+ programs or projects and almost 600 linkages to technology needs captured in the database. There is a current average of seven ongoing R&D programs per technology need; 93 percent of technology needs are covered by two or more programs, and 64 percent of technology needs are covered by five or more programs. It is clear that overlapping programs must be coordinated and, where justified, combined. The major programs that seem to best support development of the BI are Command Post of the Future, Dynamic Database, and Joint Targeting Tool.

Table D-1. *Organizations Contributing the Largest Number of Records*

Organization	No. of Records	Percent of 584
DARPA	388	66.4
AFRL/IF	66	11.3
AFOSR	21	3.6
NRL	19	3.3
Commercial	16	2.7
AFRL/HE	15	2.6
SSC-SD	15	2.6
NASA	14	2.4
NSF	13	2.2
Other	17	2.9
Total	**584**	**100.0**

Table D-2. *Programs Contributing the Largest Number of Records*

Program	No. of Records	Percent of 584
BADD	41	7.0
CPOF	33	5.7
DMIF	32	5.5
JFACC	30	5.1
DDB	29	5.0
COABS	27	4.6
GENOA	26	4.5
ALP	22	3.8
HPKB	19	3.3
AIM	13	2.2
PDA	13	2.2
COAA	11	1.9
I^3	10	1.7
JTF-ATD	10	1.7
Other	268	45.8
Total	**584**	**100.0**

A very important aspect of this assessment concerns the extent to which the 200-plus R&D programs or projects provide coverage of the technology needs for the BI. Table D-3 provides an answer to this question. Statistics of interest that can be gleaned from this table include:

- There are an average of seven ongoing R&D programs per technology need
- 93 percent of technology needs are covered by two or more programs
- 64 percent of technology needs are covered by five or more programs

Table D-3. *Program Coverage of Technology Needs*

Number of Programs Covering Technology Needs	Number of Technologies With This Coverage
1–3	23
4–6	21
7–9	15
10–12	13
13–15	5
16–18	4
19–21	2

Conclusion

The assessment reported in this Appendix leads to a fairly straightforward conclusion. The technologies needed for the BI are, for the most part, being vigorously researched throughout government and industry. There are a few areas that warrant more investment (see technologies with red maturity tags) and ongoing R&D programs are always vulnerable in the current funding climate. Nevertheless, the state of the art upon which the BI can be based is very rich indeed. To take advantage of this richness, investments in technology transfer and integration will be needed. Fortunately, however, these investments will be highly leveraged.

Technologies Database

Index of Internet Addresses

Ref	*Address*
1	http://dtsn.darpa.mil/iso/
2	http://www.darpa.mil/ito/research/edcs/index.html
3	http://www.darpa.mil/ito/research/is/index.html
4	http://www-code44.spawar.navy.mil/cpof/
5	http://www.nsf.gov/cgi-bin/showaward?award=9060164
6	http://www.nsf.gov/cgi-bin/showaward?award=9634336
7	http://olias.arc.nasa.gov/cognition/temp/roger/frj92paper/frj92.html
8	http://www.nsf.gov/cgi-bin/showaward?award=9661631
9	http://olias.arc.nasa.gov/cognition/papers/freed/aaai98.html
10	http://www.rl.af.mil/programs/ADII/adii_main.html
11	http://olias.arc.nasa.gov/projects/human-interaction-automation/three-d-primary.html
12	http://transit.larc.nasa.gov/tops/tops93/old/Exhibits/Ex_D-142e.4/EX_D-142e.4.html
13	http://duchamp.arc.nasa.gov/research/seethru_summary.html
14	http://www.faa.gov/aua/ipt_prod/oceanic/isd.htm
15	http://groucho.gsfc.nasa.gov/hostette/agents/language/
16	http://www.nsf.gov/cgi-bin/showaward?award=9311839
17	http://ctoserver.arc.nasa.gov/TechOpps/asad.html
18	http://lava.larc.nasa.gov/ABSTRACTS/LV-1998-00011.html
19	http://www.nsf.gov/cgi-bin/showaward?award=8916178
20	http://transit/larc.nasa.gov/tops/tops93/old/Exhibits/Ex_M-311/Ex_M-311.html
21	http://www-midas.arc.nasa.gov/documents/Corker_Smith.93.doc
22	http://www.nsf.gov/cgi-bin/showaward?award=9123468
23	http://www.nsf.gov/cgi-bin/showaward?award=9314992
24	http://www.nsf.gov/cgi-bin/showaward?award=9896052
25	http://pyroeis.arc.nasa.gov/SSBRP/Glovebxdataentry.html
26	http://www.faa.gov/avr/AAM/FASB597/37.htm
27	http://www.nsf.gov/cgi-bin/showaward?award=9202458
28	http://www.nsf.gov/cgi-bin/showaward?award=9528990
29	http://www.nsf.gov/cgi-bin/showaward?award=9618939
30	http://www.nsf.gov/cgi-bin/showaward?award=9113787
31	http://science.nas.nasa.gov/Pubs/TechReports/RNRreports/sbryson/ RNR-92-009/RNR-spacetime.html
32	http://olias.arc.nasa.gov/projects/bluecoat-digest/bluecoat.html
33	http://olias.arc.nasa.gov/projects/distr-team-decisions/cockpit-team-decision.html
34	http://www.nsf.gov/cgi-bin/showaward?award=8715565
35	http://www.nrl.navy.mil
36	http://www.if.afrl.af.mil/bsword/
37	http://www.darpa.mil/
38	http://www.hanscom.af.mil/
39	http://www.if.afrl.af.mil/
40	http://www.if.afrl.af.mil/tech/programs/bsword/
41	http://www.spawar.navy.mil/sandiego/welcome.page
42	http://arpi.isx.com/
43	http://www.ccbi.cmu.edu/workload.htm
44	http://www.teknowledge.com/hpkb
45	http://www.ai.mit.edu/projects/cbcl
46	http://www.safaq.hq.af.mil/restricted/aqi.html

47 http://www.he.afrl.af.mil/
48 http://www.cvc.yale.edu
49 http://www.cogen.tex.com/projects
50 http://www.parmly.luc.edu/
51 http://www.ccbi.cmu.edu/3caps.html
52 http://www.gatech.edu/psychology/
53 http://www.wolfelab.bwh.harvard.edu
54 http://www-psych.nmsu.edu/nancypg.html
n/a address not available

	P	M	E	Technologies	Technology Area	Specific Technology	Definition/Explanation	Organization	Research Programs	Program Manager	*Internet Address Reference*
1	1	G	1	Input	Identification & authentication	Source certificates	A technique to verify that a source is a recognized supplier of information.	Commercial	misc		
2	1	G	1	Input	Identification & authentication	Source certificates		DARPA ISO	GENOA	Brian Sharkey	*1*
3	1	G	1	Input	Identification & authentication	Source certificates		DARPA ISO	HPKB	Dave Gunning	*1*
4	1	G	1	Input	Identification & authentication	Source certificates		DARPA ISO	DMIF	Stephen Flank	*1*
5	1	G	1	Input	Identification & authentication	Source certificates		DARPA ISO	DDB	Tom Burns	*1*
6	1	G	1	Input	Identification & authentication	Source certificates		DARPA ISO	COABS	Doug Dyer	*1*
7	1	G	1	Input	Identification & authentication	Source certificates		DARPA ISO	ALP	Todd Carrico	*1*
8	1	G	1	Input	Identification & authentication	Source certificates		DARPA ISO	BADD	Robert Beaton	*1*
9	1	G	1	Input	Identification & authentication	Secure ID		Commercial	misc		*n/a*
10	1	G	1	Input	Identification & authentication	Secure ID		DARPA ISO	IA	Sami Sadjari	*1*
11	1	G	1	Input	Identification & authentication	Secure ID		DARPA ITO	IS	Teresa Lunt	*3*
12	1	G	1	Input	Identification & authentication	Secure ID		DARPA ISO	BADD	Robert Beaton	*1*
13	1	O	2	Input	Identification & authentication	Source availability	Monitoring access & availability, recover methods when access fails. The ability to predict or guarantee the accessibility of a particuar source, at certain QOS.	Commercial	Entertainment industry		*n/a*
14	1	O	2	Input	Identification & authentication	Source availability		DARPA ISO	BADD	Robert Beaton	*1*
15	1	B	3	Input	Identification & authentication	Source discovery	Validating or certifying information sources. The ability to locate a new source of information, based on an information need specification.	DARPA ISO	COABS	Doug Dyer	*1*
16	1	B	3	Input	Identification & authentication	Source discovery		DARPA ISO	BADD	Robert Beaton	*1*
17	2	O	2	Input	Identification & authentication	Source ID		NSA			*n/a*
18	2	O	2	Input	Identification & authentication	Source ID		NRL	ONR 6.2 Verification	C. Landwehr	*35*
19	1	B	1	Input	Access & translation	Multimedia data capture	The ability to interpret multimedia information sufficiently to provide meta-data, extract objects out of a data stream.	DARPA ISO	SAIP	Stephen Welby	*1*
20	1	B	1	Input	Access & translation	Multimedia data capture		DARPA ISO	GENOA	Brian Sharkey	*1*
21	1	B	1	Input	Access & translation	Multimedia data capture		DARPA ISO	DMIF	Stephen Flank	*1*
22	1	B	1	Input	Access & translation	Multimedia data capture		DARPA ISO	COABS	Doug Dyer	*1*
23	1	B	1	Input	Access & translation	Multimedia data capture		DARPA ISO	BADD	Robert Beaton	*1*
24	1	B	1	Input	Access & translation	Multimedia data capture		DARPA ISO	AIM	Carol Thompson	*1*
25	1	B	1	Input	Access & translation	Multimedia data capture		DARPA ISO	HPKB	Dave Gunning	*1*
26	1	O	1	Input	Access & translation	Wrapper technology		AFRL/IF	Broadsword	John Salerno	*36*
27	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	JTF ATD	Ref Dellgado	*1*
28	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	GENOA	Brian Sharkey	*1*
29	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	I*3	Dave Gunning	*1*
30	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	ALP	Todd Carrico	*1*
31	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	JFACC	Daniel McCrory	*1*
32	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	PDA	Doug Dyer	*1*
33	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	DDB	Tom Burns	*1*
34	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	BADD	Robert Beaton	*1*
35	1	O	1	Input	Access & translation	Wrapper technology		DARPA ISO	DMIF	Stephen Flank	*1*
36	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA	Information Management	Larsen	*37*
37	1	O	1	Input	Access & translation	Heterogeneous data integration		ESC	Common Data Environment	Jay Scarano	*38*
38	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA ISO	DMIF	Stephen Flank	*1*
39	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA ISO	ALP	Todd Carrico	*1*
40	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA ISO	COABS	Doug Dyer	*1*
41	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA ISO	JFACC	Daniel McCrory	*1*
42	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
43	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA ISO	I*3	Dave Gunning	*1*

	P	M	E	Technologies	Technology Area	Specific Technology	Definition/Explanation	Organization	Research Programs	Program Manager	*Internet Address Reference*
44	1	O	1	Input	Access & translation	Heterogeneous data integration	The ability to interpret multimedia information sufficiently to provide meta-data, extract objects out of a data stream.	DARPA ISO	HPKB	Dave Gunning	*1*
45	1	O	1	Input	Access & translation	Heterogeneous data integration		DARPA ISO	BADD	Robert Beaton	*1*
46	1	O	1	Input	Access & translation	Transformation techniques		DARPA ISO	I*3	Dave Gunning	*1*
47	1	O	1	Input	Access & translation	Transformation techniques		DARPA ISO	COABS	Doug Dyer	*1*
48	1	O	1	Input	Access & translation	Transformation techniques		DARPA ISO	HPKB	Dave Gunning	*1*
49	1	O	1	Input	Access & translation	Transformation techniques		DARPA ISO	JFACC	Daniel McCrory	*1*
50	1	O	1	Input	Access & translation	Transformation techniques		DARPA ISO	CPOF	Dave Gunning	*4*
51	1	O	1	Input	Access & translation	Transformation techniques		DARPA ISO	DDB	Tom Burns	*1*
52	1	O	1	Input	Access & translation	Transformation techniques		DARPA ISO	DMIF	Stephen Flank	*1*
53	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	AIM	Carol Thompson	*1*
54	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	ALP	Todd Carrico	*1*
55	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	ASTT	Dell Lunceford	*1*
56	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	DMIF	Stephen Flank	*1*
57	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	DDB	Tom Burns	*1*
58	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	CPOF	Dave Gunning	*4*
59	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	GENOA	Brian Sharkey	*1*
60	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	JFACC	Daniel McCrory	*1*
61	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
62	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	BADD	Robert Beaton	*1*
63	1	O	2	Input	Access & translation	Capture plan data		DARPA ISO	PDA	Doug Dyer	*1*
64	2	O	1	Input	Access & translation	Meeting transcription	A specific form of multimedia data capture. This refers to automatic analysis of audio from a meeting.	DARPA	Genoa (CMU, CVIM)		*37*
65	2	O	1	Input	Access & translation	Meeting transcription		DARPA ISO	CPOF	Dave Gunning	*4*
66	2	O	1	Input	Access & translation	Meeting transcription		DARPA ISO	TVRS	Allen Sears	*1*
67	1	O	1	Input	Upstream information	Tagging techniques	Representation models for data: e.g., geospatial, temporal, security, etc. Techniques to identify key characteristics of the data that will be needed for access & information management functions.	DARPA ISO	DMIF	Stephen Flank	*1*
68	1	O	1	Input	Upstream information	Tagging techniques		DARPA ISO	IA	Sami Sadjari	*1*
69	1	O	1	Input	Upstream information	Tagging techniques		DARPA ITO	IS	Teresa Lunt	*3*
70	1	O	1	Input	Upstream information	Tagging techniques		DARPA ISO	DDB	Tom Burns	*1*
71	1	O	1	Input	Upstream information	Tagging techniques		DARPA ISO	BADD	Robert Beaton	*1*
72	1	O	2	Input	Upstream information	Source characterization	The ability to capture relevant information about the source of data. Data mediation.	ESC	Data mediation for the C2 system of the future	Jay Scarano	*38*
73	1	O	2	Input	Upstream information	Source characterization	The ability to capture relevant information about the source of data. Data mediation	DARPA ISO	DMIF	Stephen Flank	*1*
74	1	O	2	Input	Upstream information	Source characterization		DARPA ISO	DDB	Robert Beaton	*1*
75	1	O	2	Input	Upstream information	Source characterization		DARPA ISO	BADD	Robert Beaton	*1*
76	1	R	2	Input	Upstream information	Capturing user intent	Capturing important information about the user's intent when data was generated.	DARPA	CPOF		*4*
77	1	R	2	Input		Capturing user intent		DARPA	ARPI		
78	1	R	2	Input		Capturing user intent		DARPA ISO	DMIF	Stephen Flank	*1*
79	1	R	2	Input		Capturing user intent		DARPA ISO	COABS	Doug Dyer	*1*
80	1	R	2	Input		Capturing user intent		DARPA ISO	HPKB	Dave Gunning	*1*
81	1	R	2	Input		Capturing user intent		DARPA ISO	DDB	Tom Burns	*1*
82	1	R	2	Input		Capturing user intent		DARPA ISO	BADD	Robert Beaton	*1*

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83	1	O	3	Input	Upstream information	Pedigree capture = source processing	Representation of credibility, appropriateness, trust & confidence of sources. The ability to capture relevant information about the processing history of a piece of information, input data, processes, etc.	DARPA ISO	DMIF	Stephen Flank	*1*
84	1	O	3	Input		Pedigree capture = source processing		DARPA ISO	DDB	Tom Burns	*1*
85	1	O	3	Input		Pedigree capture = source processing		DARPA ISO	IA	Sami Sadjari	*1*
86	1	O	3	Input		Pedigree capture = source processing		DARPA ITO	IS	Teresa Lunt	*3*
87	1	O	3	Input		Pedigree capture = source processing		DARPA ISO	BADD	Robert Beaton	*1*
88	2	R	2	Input	Categorization	Relevance (task, data)	The ability to determine the value of a piece of information to a particular context.	DARPA	DDB		*37*
89	2	R	2	Input	Categorization	Relevance (task, data)		DARPA ISO	BADD	Robert Beaton	*1*
90	1	O	2	Input	Categorization	Ontologies & taxonomies		DARPA ISO	HPKB	Dave Gunning	*1*
91	1	O	2	Input	Categorization	Ontologies & taxonomies		DARPA ISO	JFACC	Daniel McCrory	*1*
92	1	O	2	Input	Categorization	Ontologies & taxonomies		DARPA ISO	PDA	Doug Dyer	*1*
93	1	O	2	Input	Categorization	Ontologies & taxonomies		DARPA ISO	COAA	Dell Lunceford	*1*
94	1	O	2	Input	Categorization	Ontologies & taxonomies		DARPA ISO	DMIF	Stephen Flank	*1*
95	1	O	2	Input	Categorization	Ontologies & taxonomies		DARPA ISO	ALP	Todd Carrico	*1*
96	2	O	2	Input	Categorization	Expectation-driven change detection		DARPA ISO	DDB	Tom Burns	*1*
97	2	O	2	Input	Categorization	Expectation-driven change detection		DARPA ISO	SAIP	Stephen Welby	*1*
98	2	O	2	Input	Categorization	Expectation-driven change detection		DARPA ISO	MSTAR	Robert Hummel	*1*
99	2	O	2	Input	Categorization	Expectation-driven change detection		DARPA ISO	COABS	Doug Dyer	*1*
100	2	O	2	Input	Categorization	Expectation-driven change detection		DARPA ISO	ALP	Todd Carrico	*1*
101	2	O	2	Input	Categorization	Expectation-driven change detection		DARPA ISO	BADD	Robert Beaton	*1*
102	1	G	1	Manipulation	Storage	Multimedia storage	Voice, video, text, imagery, SAR.	Commercial			*n/a*
103	1	G	1	Manipulation	Storage	Multimedia storage		DARPA ISO	SAIP	Stephen Welby	*1*
104	1	G	1	Manipulation	Storage	Multimedia storage		DARPA ISO	DDB	Tom Burns	*1*
105	1	G	1	Manipulation	Storage	Multimedia storage		DARPA ISO	CPOF	Dave Gunning	*4*
106	1	G	1	Manipulation	Storage	Multimedia storage		DARPA ISO	BADD	Robert Beaton	*1*
107	1	O	2	Manipulation	Storage	Resource distribution management	Redundant with resource distribution management.	DARPA/ISO	JTF ATD—Replication services	Ref DelGado	*1*
108	1	R	2	Manipulation	Storage	Multilevel secure storage	Self-explanatory.	NSA	Dynamic Databases		*n/a*
109	1	R	2	Manipulation	Storage	Multilevel secure storage		DARPA	DDB	Tom Burns	*37*
110	1	R	2	Manipulation	Storage	Multilevel secure storage		NRL	Dara Pump, SINTRA	C. Landwehr	*35*
111	1	R	2	Manipulation	Storage	Multilevel secure storage		DARPA ISO	IA	Sami Sadjari	*1*
112	1	R	2	Manipulation	Storage	Multilevel secure storage		DARPA ITO	IS	Teresa Lunt	*3*
113	2	B	2	Manipulation	Storage	Seamless access to tertiary storage	Dynamic allocation of database for terabyte storage.	Commercial	Teradata & NCR		*n/a*
114	2	B	2	Manipulation	Storage	Seamless access to tertiary storage		NRL	CCS Archive	G. Heinle	*35*
115	2		2	Manipulation	Storage	High-performance computing		NRL	CMF HPC Facility	H. Dardy	*35*
116	3	G	1	Manipulation	Storage	Backup & recovery	How to bring a database back on line.	Commercial			*n/a*
117	3	G	1	Manipulation	Storage	Backup & recovery		NRL	CMF HPC Facility	G. Heinle	*35*
118	3	O	1	Manipulation	Storage	High-density mass storage	Large, dense memory (optical, “sugar cube,” Pond Scum, DNA, etc.).	AFRL/IF	3-D memory		*39*
119	3	B	2	Manipulation	Storage	Data warehousing	Collecting & aggregating information in advance of query.	Commercial			*n/a*
120	3	B	2	Manipulation	Storage	Data warehousing		DARPA ISO	BADD	Robert Beaton	*1*
121	3	B	2	Manipulation	Storage	Data warehousing		DARPA ISO	I*3	Dave Gunning	*1*

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122	1	G	2	Manipulation	Extraction	Access control	Enforcement & auditing of security or "need to know" privileges.	Commercial	Trusted Oracle 7; commercially available		*n/a*
123	1	G	2	Manipulation	Extraction	Access control		DARPA	Defensive Info Warfare		*37*
124	1	G	2	Manipulation	Extraction	Access control		AFRL/IF	Defensive Info Warfare		*39*
125	1	G	2	Manipulation	Extraction	Access control		DARPA ISO	IA	Sami Sadjari	*1*
126	1	G	2	Manipulation	Extraction	Access control		DARPA ITO	IS	Teresa Lunt	*3*
127	1	B	1	Manipulation	Extraction	Agent technologies	Agents supply information based on background processes that evaluate relevance of information.	DARPA ISO	COABS	Doug Dyer	*1*
128	1	B	1	Manipulation	Extraction	Agent technologies		DARPA ISO	CPOF	Dave Gunning	*4*
129	1	B	1	Manipulation	Extraction	Agent technologies		DARPA ISO	GENOA	Brian Sharkey	*1*
130	1	B	1	Manipulation	Extraction	Agent technologies		DARPA ISO	AIM	Carol Thompson	*1*
131	1	B	1	Manipulation	Extraction	Agent technologies		DARPA ISO	ALP	Todd Carrico	*1*
132	1	B	1	Manipulation	Extraction	Agent technologies		DARPA ISO	PDA	Doug Dyer	*1*
133	1	B	1	Manipulation	Extraction	Agent technologies		DARPA ISO	JFACC	Daniel McCrory	*1*
134	1	B	1	Manipulation	Extraction	Agent technologies		DARPA ISO	BADD	Robert Beaton	*1*
135	1	O	2	Manipulation	Extraction	Intelligent push technologies	Information dissemination servers—providing GBS info on demand.	DARPA ISO	BADD	Robert Beaton	*1*
136	1	O	2	Manipulation	Extraction	Intelligent push technologies	Transcription, topic detection & tracking, fact extraction.	DARPA/ISO	TRVS		*1*
137	1	O	2	Manipulation	Extraction	Intelligent push technologies		AFRL/IF	Broadsword	John Salerno	*40*
138	1	O	2	Manipulation	Extraction	Intelligent push technologies		DARPA ISO	TVRS	Allen Sears	*1*
139	1	O	2	Manipulation	Extraction	Intelligent push technologies		DARPA ISO	BADD	Robert Beaton	*1*
140	1	R	2	Manipulation	Extraction	Intent inferencing		DARPA ISO	HPKB	Dave Gunning	*1*
141	1	R	2	Manipulation	Extraction	Intent inferencing	Improved search & retrieval based on agent estimates of user request intent.	DARPA ISO	GENOA	Brian Sharkey	*1*
142	1	R	2	Manipulation	Extraction	Intent inferencing		DARPA ISO	CPOF	Dave Gunning	*4*
143	1	R	2	Manipulation	Extraction	Intent inferencing		DARPA ISO	ALP	Todd Carrico	*1*
144	1	R	2	Manipulation	Extraction	Intent inferencing		DARPA ISO	COABS	Doug Dyer	*1*
145	1	R	2	Manipulation	Extraction	Intent inferencing		DARPA ISO	BADD	Robert Beaton	*1*
146	1	R	3	Manipulation	Extraction	Dynamic access control	Adjustable access criteria according to aggregated content & criticality of decisions under way.	DARPA ISO	I*3	Dave Gunning	*1*
147	1	R	3	Manipulation	Extraction	Dynamic access control		DARPA ISO	HPKB	Dave Gunning	*1*
148	1	R	3	Manipulation	Extraction	Dynamic access control		DARPA ISO	COABS	Doug Dyer	*1*
149	1	R	3	Manipulation	Extraction	Dynamic access control		DARPA ISO	JFACC	Ref Dellgado	*1*
150	1	R	3	Manipulation	Extraction	Dynamic access control		DARPA ISO	GENOA	Brian Sharkey	*1*
151	1	R	3	Manipulation	Extraction	Dynamic access control		DARPA ISO	ALP	Todd Carrico	*1*
152	1	R	3	Manipulation	Extraction	Dynamic access control		DARPA ISO	DMIF	Stephen Flank	*1*
153	1	R	3	Manipulation	Extraction	Dynamic access control		DARPA ISO	BADD	Robert Beaton	*1*
154	2	O	3	Manipulation	Extraction	Information usage analysis	Automatic courses of action analysis.	DARPA ISO	COAA	Doug Dyer	*1*
155	2	O	3	Manipulation	Extraction	User modeling		DARPA ISO	BADD	Robert Beaton	*1*
156	2	O	3	Manipulation	Extraction	User modeling		DARPA ISO	DMIF	Stephen Flank	*1*
157	2	O	3	Manipulation	Extraction	User modeling		DARPA ISO	DDB	Tom Burns	*1*
158	2	O	3	Manipulation	Extraction	User modeling		DARPA ISO	CPOF	Dave Gunning	*4*
159	2	O	3	Manipulation	Extraction	User modeling		DARPA ISO	COABS	Doug Dyer	*1*
160	1	O	1	Manipulation	Decision support	Structuring	Representation of alternatives, attributes, consequences, etc.	AFRL/IF	ARPI	R. Metzger	*42*
161	1	O	1	Manipulation	Decision support	Structuring		AFRL/IF		C. DeFranco	*39*
162	1	O	1	Manipulation	Decision support	Structuring		NSF	Automated Problem Structuring Techniques		*5*
163	1	O	1	Manipulation	Decision support	Structuring		DARPA/ISO	CPOF	Dave Gunning	*4*
164	1	O	1	Manipulation	Decision support	Structuring		DARPA/IS	C2 Programs		*1*
165	1	O	1	Manipulation	Decision support	Structuring		SSC-SD		J. Morrison	*41*

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166	1	O	1	Manipulation	Decision support	Structuring	Representation of alternatives, attributes, consequences, etc.	DARPA ISO	PDA	Doug Dyer	*1*
167	1	O	1	Manipulation	Decision support	Structuring		DARPA ISO	JFACC	Daniel McCrory	*1*
168	1	O	1	Manipulation	Decision support	Structuring		DARPA ISO	COAA	Doug Dyer	*1*
169	1	O	1	Manipulation	Decision support	Structuring		DARPA ISO	ALP	Todd Carrico	*1*
170	1	O	1	Manipulation	Decision support	Structuring		DARPA ISO	GENOA	Brian Sharkey	*1*
171	1	O	2	Manipulation	Decision support	Advice	Recommended courses of action.	RL	ARPI	R. Metzger	*42*
172	1	O	2	Manipulation	Decision support	Advice		AFRL/IF	Joint Targeting Toolkit	J. Palermo	*39*
173	1	O	2	Manipulation	Decision support	Advice		AFRL/IF		C. DeFranco	*39*
174	1	O	2	Manipulation	Decision support	Advice		DARPA	PDA	Doug Dyer	*1*
175	1	O	2	Manipulation	Decision support	Advice		SSC-SD		Morrison/Larsen	*41*
176	1	O	2	Manipulation	Decision support	Advice		DARPA ISO	COAA	Dell Lunceford	*1*
177	1	O	2	Manipulation	Decision support	Advice		DARPA ISO	JFACC	Daniel McCrory	*1*
178	1	O	2	Manipulation	Decision support	Advice		DARPA ISO	ALP	Todd Carrico	*1*
179	1	O	2	Manipulation	Decision support	Advice		DARPA ISO	GENOA	Brian Sharkey	*1*
180	2	O	1	Manipulation	Decision support	Uncertainty portrayal	Representation of missing, unreliable, indeterminate, & complex info.	AFRL/IF	HPKB	C. Anken	*44*
181	2	O	1	Manipulation	Decision support	Uncertainty portrayal		AFRL/IF		C. DeFranco	*39*
182	2	O	1	Manipulation	Decision support	Uncertainty portrayal		AFRL/IF	ARPI	R. Metzger	*42*
183	2	O	1	Manipulation	Decision support	Uncertainty portrayal		NSF	Multiple Objectives, Risk Evaluation & Visualization		*6*
184	2	O	1	Manipulation	Decision support	Uncertainty portrayal		NASA	Involuntary Covert Orienting		*7*
185	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA/IS	Exploitation	Garvey/Strat	*1*
186	2	O	1	Manipulation	Decision support	Uncertainty portrayal		AFOSR		T. Poggio	*45*
187	2	O	1	Manipulation	Decision support	Uncertainty portrayal		SSC-SD		R. Smillie	*41*
188	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA ISO	DMIF	Stephen Flank	*1*
189	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA ISO	DDB	Tom Burns	*1*
190	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA STO	MTE	Bruce Johnson	*37*
191	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA ISO	JFACC	Daniel McCrory	*1*
192	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA ISO	GENOA	Brian Sharkey	*1*
193	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA ISO	CPOF	Dave Gunning	*4*
194	2	O	1	Manipulation	Decision support	Uncertainty portrayal		DARPA ISO	SAIP	Stephen Welby	*1*
195	2	O	2	Manipulation	Decision support	Tradeoff management	Representation & assessment of benefits & costs.	AFRL/IF		C. DeFranco	*39*
196	2	O	2	Manipulation	Decision support	Tradeoff management		DARPA	ARPI		*37*
197	2	O	2	Manipulation	Decision support	Tradeoff management		NSF	Decision Support for Managing Performance Risk		*n/a*
198	2	O	2	Manipulation	Decision support	Tradeoff management		NASA	Managing Multiple Tasks in Complex, Dynamic Environments		*9*
199	2	O	2	Manipulation	Decision support	Tradeoff management		NRL	6.2 & 6.3 Planning	J. Hoffman	*35*
200	2	O	2	Manipulation	Decision support	Tradeoff management		SSC-SD		R. Larsen	*41*
201	2	O	2	Manipulation	Decision support	Tradeoff management		DARPA ISO	PDA	Doug Dyer	*1*
202	2	O	2	Manipulation	Decision support	Tradeoff management		DARPA ISO	JFACC	Daniel McCrory	*1*
203	2	O	2	Manipulation	Decision support	Tradeoff management		DARPA ISO	CPOF	Dave Gunning	*4*
204	2	O	2	Manipulation	Decision support	Tradeoff management		DARPA ISO	ALP	Todd Carrico	*1*
205	2	O	2	Manipulation	Decision support	Tradeoff management		DARPA ISO	AIM	Carol Thompson	*1*

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206	1	G	1	Manipulation	Aggregation & fusion	Video compression	Commercial media compression.	Commercial			*n/a*
207	1	G	1	Manipulation	Aggregation & fusion	Video compression		DARPA ISO	BADD	Robert Beaton	*1*
208	1	G	2	Manipulation	Aggregation & fusion	Video compression	Recognition of the changed portion of the picture & compression or transmission of only the changed pixels.	DARPA/ISO	(MPEG) Image Bandwidth Compression		*1*
209	1	G	2	Manipulation	Aggregation & fusion	Video compression		DARPA ISO	IBC	Robert Hummel	*1*
210	1	G	2	Manipulation	Aggregation & fusion	Video compression		DARPA ISO	BADD	Robert Beaton	*1*
211	1	O	1	Manipulation	Aggregation & fusion	Wrapping legacy systems	Preparing legacy systems to participate in the InfoSphere.	DARPA ISO	DMIF	Stephen Flank	*1*
212	1	O	1	Manipulation	Aggregation & fusion	Wrapping legacy systems		DARPA ISO	ALP	Todd Carrico	*1*
213	1	O	1	Manipulation	Aggregation & fusion	Wrapping legacy systems		DARPA ISO	BADD	Robert Beaton	*1*
214	1	O	1	Manipulation	Aggregation & fusion	Information synchronization	Finding, linking, & fusing information that is related.	DARPA ISO	DMIF	Stephen Flank	*1*
215	1	O	1	Manipulation	Aggregation & fusion	Information synchronization		DARPA ISO	BADD	Robert Beaton	*1*
216	1	O	1	Manipulation	Aggregation & fusion	Information synchronization		DARPA ISO	DDB	Tom Burns	*1*
217	1	O	1	Manipulation	Aggregation & fusion	Information synchronization		DARPA ISO	GENOA	Brian Sharkey	*1*
218	1	O	1	Manipulation	Aggregation & fusion	Information synchronization		DARPA ISO	JFACC	Daniel McCrory	*1*
219	1	O	1	Manipulation	Aggregation & fusion	Information synchronization		DARPA ISO	AIM	Carol Thompson	*1*
220	1	O	1	Manipulation	Aggregation & fusion	Information synchronization		DARPA ISO	ALP	Todd Carrico	*1*
221	1	O	1	Manipulation	Aggregation & fusion	Geospatial & temporal indexing	Standards for reporting information (WGS-84).	NIMA			*n/a*
222	1	O	1	Manipulation	Aggregation & fusion	Geospatial & temporal indexing		DARPA/ISO	Dynamic Data Base	Tom Burns	*1*
223	1	O	1	Manipulation	Aggregation & fusion	Geospatial & temporal indexing		DARPA ISO	DDB	Tom Burns	*1*
224	1	O	1	Manipulation	Aggregation & fusion	Geospatial & temporal indexing		DARPA ISO	BADD	Robert Beaton	*1*
225	1	O	2	Manipulation	Aggregation & fusion	Object extraction for compression		DARPA/ISO	I BC, MSTARS	Tom Burns	*1*
226	1	O	2	Manipulation	Aggregation & fusion	Object extraction for compression		DARPA ISO	IBC	Robert Hummel	*1*
227	1	O	2	Manipulation	Aggregation & fusion	Meta-data language	A language in which other languages can be described. A language for agents to talk to one another.	DARPA	CoABS	Doug Dyer	*1*
228	1	O	2	Manipulation	Aggregation & fusion	Meta-data language		DARPA ITO	EDCS	John Salasin	*3*
229	1	O	2	Manipulation	Aggregation & fusion	Meta-data language		DARPA STO	MTE	Bruce Johnson	*37*
230	1	O	2	Manipulation	Aggregation & fusion	Meta-data language		DARPA ISO	IU	George Lukes	*1*
231	1	O	2	Manipulation	Aggregation & fusion	Meta-data language		DARPA ISO	BADD	Robert Beaton	*1*
232	1	O	3	Manipulation	Aggregation & fusion	Data fusion	Automated analysis of info to produce new products.	AFRL/IF	Enhanced All Source Fusion		*39*
233	1	O	3	Manipulation	Aggregation & fusion	Data fusion		DARPA ISO	DMIF	Stephen Flank	*1*
234	1	O	3	Manipulation	Aggregation & fusion	Data fusion		DARPA ISO	DDB	Tom Burns	*1*
235	1	O	3	Manipulation	Aggregation & fusion	Data fusion		DARPA ISO	SAIP	Stephen Welby	*1*
236	1	O	3	Manipulation	Aggregation & fusion	Data fusion		DARPA ISO	MSTAR	Robert Hummel	*1*
237	1	O	3	Manipulation	Aggregation & fusion	Data fusion		DARPA STO	MTE	Bruce Johnson	*37*
238	2	R	2	Manipulation	Aggregation & fusion	Information life cycle	Maintenance of information currency & history, & knowing when to get rid of data.	DARPA/ISO	IA program	Sadjari	*1*
239	2	R	2	Manipulation	Aggregation & fusion	Information life cycle		DARPA ISO	DDB	Tom Burns	*1*
240	2	R	2	Manipulation	Aggregation & fusion	Information life cycle		DARPA ISO	DMIF	Stephen Flank	*1*
241	2	R	2	Manipulation	Aggregation & fusion	Information life cycle		DARPA ISO	I*3	Dave Gunning	*1*
242	2	O	3	Manipulation	Aggregation & fusion	Database mediation	Analyzing & interpreting information.	DARPA ISO	COABS	Doug Dyer	*1*
243	2	O	3	Manipulation	Aggregation & fusion	Database mediation		DARPA ISO	I*3	Dave Gunning	*1*
244	2	O	3	Manipulation	Aggregation & fusion	Database mediation		DARPA ISO	HPKB	Dave Gunning	*1*
245	2	O	3	Manipulation	Aggregation & fusion	Database mediation		DARPA ISO	DDB	Tom Burns	*1*
246	2	O	3	Manipulation	Aggregation & fusion	Database mediation		DARPA ISO	DMIF	Stephen Flank	*1*
247	2	O	3	Manipulation	Aggregation & fusion	Database mediation		DARPA ISO	JFACC	Daniel McCrory	*1*
248	2	O	3	Manipulation	Aggregation & fusion	Database mediation		DARPA ISO	CPOF	Dave Gunning	*4*

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249	3	O	3	Manipulation	Aggregation & fusion	Rapid knowledge formation	Data mining on steroids.	AFRL/IF	Video Exorcist		*39*
250	3	O	3	Manipulation	Aggregation & fusion	Rapid knowledge formation		DARPA	Rapid Knowledge Formation		*37*
251	3	O	3	Manipulation	Aggregation & fusion	Rapid knowledge formation		DARPA ISO	GENOA	Brian Sharkey	*1*
252	3	O	3	Manipulation	Aggregation & fusion	Rapid knowledge formation		DARPA ISO	DDB	Tom Burns	*1*
253	3	O	3	Manipulation	Aggregation & fusion	Rapid knowledge formation	Intelligent integration of information.	DARPA ISO	I*3	Dave Gunning	*1*
254	3	O	3	Manipulation	Aggregation & fusion	Rapid knowledge formation		DARPA ISO	COABS	Doug Dyer	*1*
255	1	B	1	Manipulation	Accessing	Collaboration technologies	Two or more individuals or systems collaborate with one another.	ESC	CVW		*38*
256	1	B	2	Manipulation	Accessing	Collaboration technologies		Commercial	Lotusnotes, Placewares, Netmeeting, etc.		*n/a*
257	1	B	2	Manipulation	Accessing	Collaboration technologies		DARPA ISO	COABS	Doug Dyer	*1*
258	1	B	2	Manipulation	Accessing	Collaboration technologies		DARPA ISO	ALP	Todd Carrico	*1*
259	1	B	2	Manipulation	Accessing	Collaboration technologies		DARPA ITO	EDCS	John Salasin	*3*
260	1	B	2	Manipulation	Accessing	Collaboration technologies		DARPA ISO	JFACC	Daniel McCrory	*1*
261	1	B	2	Manipulation	Accessing	Collaboration technologies		DARPA ISO	AIM	Carol Thompson	*1*
262	1	O	2	Manipulation	Accessing	Self-healing networks	Restoring networks as they suffer breakage.	AFRL/IF	SurvNet		*39*
263	1	O	2	Manipulation	Accessing	Self-healing networks		DARPA/ISO	Active Networks		*1*
264	1	O	2	Manipulation	Accessing	Self-healing networks		NRL	Networking 6.1 & 6.2	J. Wieseltheir	*35*
265	1	O	2	Manipulation	Accessing	Self-healing networks		DARPA ISO	BADD	Robert Beaton	*1*
266	1	R	2	Manipulation	Accessing	Multilevel access (e.g., for security management)	Reaching in & pulling it out for labeling.	DARPA ISO	IA	Sami Sadjari	*1*
267	1	R	2	Manipulation	Accessing	Multilevel access (e.g., for security management)		DARPA ITO	IS	Teresa Lunt	*3*
268	2	O	2	Manipulation	Accessing	Parallel access for speed	Multiple processor database access.	Commercial	Inktomi		*n/a*
269	2	O	2	Manipulation	Accessing	Parallel access for speed	Use of confidence in analysis of information. Check for contradictions with current belief state.	SPAWAR	Heterogenous network access	Richard Freund	*41*
270	1	O	2	Manipulation	Labeling	Uncertainty		DARPA/ISO	CPOF	Dave Gunning	*4*
271	1	O	2	Manipulation	Labeling	Uncertainty		DARPA ISO	DMIF	Stephen Flank	*1*
272	1	O	2	Manipulation	Labeling	Uncertainty		DARPA STO	MTE	Bruce Johnson	*37*
273	1	O	2	Manipulation	Labeling	Uncertainty		DARPA ISO	DDB	Tom Burns	*1*
274	1	O	2	Manipulation	Labeling	Uncertainty		DARPA ISO	JFACC	Daniel McCrory	*1*
275	1	O	2	Manipulation	Labeling	Uncertainty		DARPA ISO	COABS	Doug Dyer	*1*
276	1	O	2	Manipulation	Labeling	Uncertainty		DARPA ISO	COAA	Dell Lunceford	*1*
277	2	O	1	Manipulation	Labeling	Domain-specific taxonomies & ontologies		DARPA/ISO	HPKP		*1*
278	2	O	1	Manipulation	Labeling	Domain-specific taxonomies & ontologies		DARPA ISO	ALP	Todd Carrico	*1*
279	2	O	1	Manipulation	Labeling	Domain-specific taxonomies & ontologies		DARPA ISO	JFACC	Daniel McCrory	*1*
280	2	O	2	Manipulation	Understanding	Dynamic situation modeling		AFRL/IF	HPKB	C. Anken	*44*
281	2	O	2	Manipulation	Understanding	Dynamic situation modeling		AFRL/IF	Enabling Tech for M&S	A. Sisti	*39*
282	2	O	2	Manipulation	Understanding	Dynamic situation modeling		AFRL/IF	Collaboration Enterprise Tech	B. McQuay	*39*
283	2	O	2	Manipulation	Understanding	Dynamic situation modeling		AFOSR		M. Just	*43*

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284	2	O	2	Manipulation	Understanding	Dynamic situation modeling	Use of confidence in analysis of information. Check for contradictions with current belief state.	AFOSR		M. Just	*51*
285	2	O	2	Manipulation	Understanding	Dynamic situation modeling		DARPA/IS	C2 Programs		*1*
286	2	O	2	Manipulation	Understanding	Dynamic situation modeling		SSC-SD		D. Hardy	*41*
287	2	O	2	Manipulation	Understanding	Dynamic situation modeling		DARPA ISO	DDB	Tom Burns	*1*
288	2	O	2	Manipulation	Understanding	Dynamic situation modeling		DARPA ISO	DMIF	Stephen Flank	*1*
289	2	O	2	Manipulation	Understanding	Sensitivity analysis		AFRL/IF	Timeline Analysis System	J. Mucks	*39*
290	2	O	2	Manipulation	Understanding	Sensitivity analysis		AFRL/IF	Enabling Tech for M&S	A. Sisti	*39*
291	2	O	2	Manipulation	Understanding	Sensitivity analysis		AFRL/IF	ARPI	R. Metzger	*42*
292	2	O	2	Manipulation	Understanding	Sensitivity analysis		AFRL/IF		C. DeFranco	*39*
293	2	O	2	Manipulation	Understanding	Sensitivity analysis		DARPA	PDA	Doug Dyer	*1*
294	2	O	2	Manipulation	Understanding	Sensitivity analysis		DARPA/IS	C2 Programs	Garvey/Shark	*1*
295	2	O	2	Manipulation	Understanding	Sensitivity analysis		DARPA ISO	COAA	Dell Lunceford	*1*
296	2	O	2	Manipulation	Understanding	Sensitivity analysis		DARPA ISO	AIM	Carol Thompson	*1*
297	2	O	2	Manipulation	Understanding	Sensitivity analysis		DARPA ISO	JFACC	Daniel McCrory	*1*
298	2	O	2	Manipulation	Understanding	Sensitivity analysis		DARPA ISO	GENOA	Brian Sharkey	*1*
299	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.		Commercial	Commercial		*n/a*
300	1	G	1	Information access	Routing			NRL	ATDnet	H. Dardy	*35*
301	1	G	1	Information access	Routing			DARPA ISO	BADD	Robert Beaton	*1*
302	1	G	1	Information access	Routing			AFRL/IF	Information for the Warrior		*39*
303	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.	Airborne relays.	AFRL/IF	UAV Airborne Switch		*39*
304	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.		NRL		H. Dardy	*35*
305	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.		DARPA ISO	BADD	Robert Beaton	*1*
306	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.	Integrated Broadcast Service.	SAF/AQIJ	IBS	Lt Col R. Fullerton	*46*
307	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.		DARPA ISO	BADD	Robert Beaton	*1*
308	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.	Global Grid.	AFSC2A	Global Grid	Col Jack Fellows	*n/a*
309	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.		NRL	ATDnet	H. Dardy	*35*
310	1	G	1	Information access	Routing	Internet, ATM switching, broadcast technologies, etc.		DARPA ISO	BADD	Robert Beaton	*1*
311	1	O	2	Information access	Routing	Dynamic bandwidth management	Bandwidth management—dynamic allocation of bandwidth on a channel to respond to changing priorities	DARPA/ISO	AICE		*1*
312	1	O	2	Information access	Routing	Dynamic bandwidth management		AFRL/IF	Info for the Warrior		*39*
313	1	O	2	Information access	Routing	Dynamic bandwidth management		NRL	STOWnets	R. Cole	*35*
314	1	O	2	Information access	Routing	Dynamic bandwidth management		DARPA ISO	BADD	Robert Beaton	*1*

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315	3	R	3	Information access	Routing	Meta-networks	Connection management—network structure to link any information source to any sink. Agile Information Control Environment.	DARPA/ISO	AICE		*1*
316	3	R	3	Information access	Routing	Meta-networks		AFRL/IF	Survivable ATM		*39*
317	3	R	3	Information access	Routing	Meta-networks		NRL	ATDnet	H. Dardy	*35*
318	3	R	3	Information access	Routing	Meta-networks		DARPA ISO	BADD	Robert Beaton	*1*
319	1	G	1	Information access	Transmission	Assured delivery	Protocols to ensure that information is delivered intact.	Commercial			*n/a*
320	1	G	1	Information access	Transmission	Assured delivery		DARPA	Information Assurance Technology	S. Sadjari	*37*
321	1	G	1	Information access	Transmission	Assured delivery		DARPA ISO	BADD	Robert Beaton	*1*
322	2	G	1	Information access	Transmission	Nonrepudiation		Commercial	Public Key Verification		*n/a*
323	2	G	1	Information access	Transmission	Nonrepudiation	Protocols to prove information was delivered.	NRL	Network Protocols	C. Meadows	*35*
324	3	R	2	Information access	Transmission	Downstream tracking		NRL	Network Protocols	C. Meadows	*35*
325	1	B	1	Information access	Perception	3-D visualization	3-D visual displays, including animation.	AFRL/IF		P. Jedrysik	*10*
326	1	B	1	Information access	Perception	3-D visualization		NASA	3-D Flight Displays		*11*
327	1	B	1	Information access	Perception	3-D visualization		NASA	Helmet-Mounted Displays		*12*
328	1	B	1	Information access	Perception	3-D visualization		NASA	See-Through Displays		*13*
329	1	B	1	Information access	Perception	3-D visualization		FAA	Air Traffic Visualization		*14*
330	1	B	1	Information access	Perception	3-D visualization		NRL	Immersive VR	L. Rosenblum	*35*
331	1	B	1	Information access	Perception	3-D visualization		AFRL/HE		M. Haas	*47*
332	1	B	1	Information access	Perception	3-D visualization		DARPA/IS	CPOF		*4*
333	1	B	1	Information access	Perception	3-D visualization		AF/ESC		P. Hughes	*38*
334	1	B	1	Information access	Perception	3-D visualization		AFOSR		M. Just	*43*
335	1	B	1	Information access	Perception	3-D visualization		AFOSR		T. Poggio	*45*
336	1	B	1	Information access	Perception	3-D visualization		AFOSR		S. Kosslyn	*n/a*
337	1	B	1	Information access	Perception	3-D visualization		AFOSR		S. Zucker	*48*
338	1	B	1	Information access	Perception	3-D visualization		SSC-SD		M. Cowan	*41*
339	1	B	1	Information access	Perception	3-D visualization		DARPA ISO	BADD	Robert Beaton	*1*
340	1	B	1	Information access	Perception	3-D visualization		DARPA ISO	AVS	Stephen Hennesy	*1*
341	1	B	1	Information access	Perception	Natural language	Natural language presentations—visual or audio.	AFRL/IF	NL Generation	D. Cerino	*49*
342	1	B	1	Information access	Perception	Natural language		NASA	Agent Language Technology		*15*
343	1	B	1	Information access	Perception	Natural language		NRL	Multimodal-Multimedia	E. Marsh	*35*
344	1	B	1	Information access	Perception	Natural language		AFRL/HE		T. Andersen	*47*
345	1	B	1	Information access	Perception	Natural language		AFOSR		M. Just	*43*

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346	1	B	1	Information access	Perception	Natural language	Natural language presentations—visual or audio.	SSC-SD		B. Sundheim	*41*
347	1	B	1	Information access	Perception	Natural language		DARPA ISO	GENOA	Brian Sharkey	*1*
348	1	B	1	Information access	Perception	Natural language		DARPA ISO	CPOF	Dave Gunning	*4*
349	1	B	1	Information access	Perception	Natural language		DARPA ISO	COABS	Doug Dyer	*1*
350	1	B	1	Information access	Perception	Natural language		DARPA ISO	TVRS	Allen Sears	*1*
351	1	B	1	Information access	Perception	Nontraditional senses	Olfactory, tactile, etc., queueing.	Commercial/ entertainment			*n/a*
352	1	B	1	Information access	Perception	Nontraditional senses		AFRL/IF	Information Exploitation Technology	C. Pine	*39*
353	1	O	1	Information access	Perception	Drilldown	Drilldown capabilities for explaining presentations.	AFRL/IF	ARPI	R. Metzger	*42*
354	1	O	1	Information access	Perception	Drilldown		AFRL/IF		C. Burns	*39*
355	1	O	1	Information access	Perception	Drilldown		AFRL/IF		J. Salerno	*39*
356	1	O	1	Information access	Perception	Drilldown		AFRL/IF	JFACC	C. DeFranco	*39*
357	1	O	1	Information access	Perception	Drilldown		NSF	Human-Centered Intelligent Agents Supporting Communication & Collaboration		*n/a*
358	1	O	1	Information access	Perception	Drilldown		AFRL/HE		M. Young	*47*
359	1	O	1	Information access	Perception	Drilldown		DARPA ISO	DMIF	Stephen Flank	*1*
360	1	O	1	Information access	Perception	Drilldown		DARPA ISO	DDB	Tom Burns	*1*
361	1	O	1	Information access	Perception	Drilldown		DARPA ISO	I*3	Dave Gunning	*1*
362	1	O	1	Information access	Perception	Drilldown		DARPA ISO	GENOA	Brian Sharkey	*1*
363	1	O	1	Information access	Perception	Drilldown		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
364	1	O	1	Information access	Perception	Drilldown		DARPA ISO	JFACC	Daniel McCrory	*1*
365	1	O	1	Information access	Perception	Drilldown		DARPA ISO	PDA	Doug Dyer	*1*
366	1	O	1	Information access	Perception	Drilldown		DARPA ISO	HPKB	Dave Gunning	*1*
367	1	O	1	Information access	Perception	Drilldown		DARPA ISO	COAA	Dell Lunceford	*1*
368	1	O	1	Information access	Perception	Drilldown		DARPA ISO	CPOF	Dave Gunning	*4*
369	1	O	1	Information access	Perception	Drilldown		DARPA ISO	COABS	Doug Dyer	*1*
370	2	B	2	Information access	Perception	3-D audio	3-D audio displays.	AFRL/HE	3D Audio		*47*
371	2	B	2	Information access	Perception	3-D audio		DARPA	Virtual Reality		*37*
372	2	B	2	Information access	Perception	3-D audio		NASA	Spatial Auditory Display		*17*
373	2	B	2	Information access	Perception	3-D audio		NASA	Low-Vis Landing & Surface Ops		*18*
374	2	B	2	Information access	Perception	3-D audio		NRL	Decision Making	J. Ballas	*35*
375	2	B	2	Information access	Perception	3-D audio		AFRL/HE		R. McKinley	*47*
376	2	B	2	Information access	Perception	3-D audio		AFOSR		W. Yost	*50*

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377	2	B	2	Information access	Perception	3-D audio	3-D audio displays.	SSC-SD		J. Kaiwi	*41*
378	2	B	2	Information access	Perception	3-D audio		DARPA ISO	CPOF	Dave Gunning	*4*
379	2	O	2	Information access	Perception	Tailoring	Adaptation of presentations to particular users & current tasks.	AFRL/IF	BROADSWORD	J. Salerno	*40*
380	2	O	2	Information access	Perception	Tailoring		AFRL/IF		C. DeFranco	*39*
381	2	O	2	Information access	Perception	Tailoring		AFRL/IF		P. Jedrysik	*39*
382	2	O	2	Information access	Perception	Tailoring		NSF	Advanced User Interface for Network Access to Multiple Databases		*19*
383	2	O	2	Information access	Perception	Tailoring		DARPA	Intelligent collaboration & visualization	Kevin Mills	*37*
384	2	O	2	Information access	Perception	Tailoring		C2TIC	ELVIS		*n/a*
385	2	O	2	Information access	Perception	Tailoring		NRL	Multimodal-Multimedia	E. Marsh	*35*
386	2	O	2	Information access	Perception	Tailoring		AFRL/HE		M. Haas	*n/a*
387	2	O	2	Information access	Perception	Tailoring		DARPA/IS	CPOF		*4*
388	2	O	2	Information access	Perception	Tailoring		DARPA ISO	DMIF	Stephen Flank	*1*
389	2	O	2	Information access	Perception	Tailoring		DARPA ISO	GENOA	Brian Sharkey	*1*
390	2	O	2	Information access	Perception	Tailoring		DARPA ISO	CPOF	Dave Gunning	*4*
391	2	O	2	Information access	Perception	Tailoring		DARPA ISO	COABS	Doug Dyer	*1*
392	2	O	2	Information access	Perception	Tailoring		DARPA ISO	HPKB	Dave Gunning	*1*
393	2	O	2	Information access	Perception	Tailoring		DARPA ISO	JFACC	Daniel McCrory	*1*
394	1	O	1	Information access	User modeling	Info needs models	Embedded understanding of information needs for situations & tasks.	AFRL/IF		C. Burns	*39*
395	1	O	1	Information access	User modeling	Info needs models		AFRL/IF	Broadsword	J.Salerno	*40*
396	1	O	1	Information access	User modeling	Info needs models		AFRL/IF		C. DeFranco	*39*
397	1	O	1	Information access	User modeling	Info needs models		NASA	Cockpit Weather Information Needs		*20*
398	1	O	1	Information access	User modeling	Info needs models		NASA	Crew Station Design		*21*
399	1	O	1	Information access	User modeling	Info needs models		NRL	Decision Making	J. Ballas	*35*
400	1	O	1	Information access	User modeling	Info needs models		AFRL/HE		M. Haas	*47*
401	1	O	1	Information access	User modeling	Info needs models		AFOSR		M. Just	*51*
402	1	O	1	Information access	User modeling	Info needs models		AFOSR		R. Engle	*52*
403	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	BADD	Robert Beaton	*1*
404	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	DMIF	Stephen Flank	*1*
405	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	GENOA	Brian Sharkey	*1*
406	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	COAA	Dell Lunceford	*1*
407	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	AIM	Carol Thompson	*1*

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408	1	O	1	Information access	User modeling	Info needs models	Understanding of information needs for situations & tasks.	DARPA ISO	COABS	Doug Dyer	*1*
409	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	ALP	Todd Carrico	*1*
410	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	DDB	Tom Burns	*1*
411	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	CPOF	Dave Gunning	*4*
412	1	O	1	Information access	User modeling	Info needs models		DARPA ISO	JFACC	Daniel McCrory	*1*
413	1	O	1	Information access	User modeling	Dialog management		RL	HPKB	C. Anken	*44*
414	1	O	1	Information access	User modeling	Dialog management		RL	Broadsword		*39*
415	1	O	1	Information access	User modeling	Dialog management		RL		C. DeFranco	*39*
416	1	O	1	Information access	User modeling	Dialog management		DARPA/ITO	Communicator	A. Sears	*3*
417	1	O	1	Information access	User modeling	Dialog management		NSF	Pattern-Driven User Interfaces		*22*
418	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	BADD	Robert Beaton	*1*
419	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	DMIF	Stephen Flank	*1*
420	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	GENOA	Brian Sharkey	*1*
421	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	CPOF	Dave Gunning	*4*
422	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	JFACC	Daniel McCrory	*1*
423	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	COABS	Doug Dyer	*1*
424	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	COAA	Dell Lunceford	*1*
425	1	O	1	Information access	User modeling	Dialog management		DARPA ISO	PDA	Doug Dyer	*1*
426	2	R	3	Information access	User modeling	Context Understanding	Real-time understanding of user(s)' situation & tasks at hand.	AFRL/IF	Enhanced All Source Fusion	M. Hinman	*39*
427	2	R	3	Information access	User modeling	Context Understanding		AFRL/IF		C. DeFranco	*39*
428	2	R	3	Information access	User modeling	Context Understanding		AFRL/HE		G. Reid	*47*
429	2	R	3	Information access	User modeling	Context Understanding		DARPA/IS	CPOF		*4*
430	2	R	3	Information access	User modeling	Context Understanding		AFOSR		T. Poggio	*45*
431	2	R	3	Information access	User modeling	Context Understanding		AFOSR		J. Wolfe	*53*
432	2	R	3	Information access	User modeling	Context Understanding		AFOSR		N. Cooke	*54*
433	2	R	3	Information access	User modeling	Context Understanding		AFOSR		R. Engle	*52*
434	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	BADD	Robert Beaton	*1*
435	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	DMIF	Stephen Flank	*1*
436	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	DDB	Tom Burns	*1*
437	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	JFACC	Daniel McCrory	*1*
438	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	GENOA	Brian Sharkey	*1*

	P	M	E	Technologies	Technology Area	Specific Technology	Definition/Explanation	Organization	Research Programs	Program Manager	*Internet Address Reference*
439	2	R	3	Information access	User modeling	Context Understanding	Real-time understanding of user(s)' situation & tasks at hand.	DARPA ISO	ALP	Todd Carrico	*1*
440	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	COABS	Doug Dyer	*1*
441	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	CPOF	Dave Gunning	*4*
442	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	HPKB	Dave Gunning	*1*
443	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	COAA	Dell Lunceford	*1*
444	2	R	3	Information access	User modeling	Context Understanding		DARPA ISO	AIM	Carol Thompson	*1*
445	2	R	3	Information access	User modeling	Intent inferencing	Real-time Understanding of user(s)' goals, plans, & preferences.	AFRL/IF	ARPI	R. Metzger	*42*
446	2	R	3	Information access	User modeling	Intent inferencing		AFRL/IF	Joint Targeting Toolkit	J. Palermo	*39*
447	2	R	3	Information access	User modeling	Intent inferencing		DARPA	PDA	Doug Dyer	*1*
448	2	R	3	Information access	User modeling	Intent inferencing		NSF	Multitext Fusion, Tracking & Trend Detection		*23*
449	2	R	3	Information access	User modeling	Intent inferencing		AFOSR		A. Gevins	*n/a*
450	2	R	3	Information access	User modeling	Intent inferencing		AFOSR		N. Cooke	*54*
451	2	R	3	Information access	User modeling	Intent inferencing		AFOSR		R. Engle	*52*
452	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	BADD	Robert Beaton	*1*
453	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	DMIF	Stephen Flank	*1*
454	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	JFACC	Daniel McCrory	*1*
455	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	HPKB	Dave Gunning	*1*
456	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	COABS	Doug Dyer	*1*
457	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	ALP	Todd Carrico	*1*
458	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	AIM	Carol Thompson	*1*
459	2	R	3	Information access	User modeling	Intent inferencing		DARPA ISO	CPOF	Dave Gunning	*4*
460	1	G	1	Information access	Protection	Encryption	Encryption tools compatible with route & transmit configurations.	Commercial			*n/a*
461	1	G	1	Information access	Protection	Encryption		AFRL/IF	Secure Handling of Information		*39*
462	1	G	1	Information access	Protection	Encryption		AFRL/IF	Speakeasy (programmable encryption)		*39*
463	1	G	1	Information access	Protection	Encryption		DARPA ISO	IA	Sami Sadjari	*1*
464	1	G	1	Information access	Protection	Encryption		DARPA ITO	IS	Teresa Lunt	*3*
465	1	O	1	Information access	Protection	Recall of inaccurate information	Ability to chase down erroneous info & retract it from all users who exploited it.	AFRL/IF	Broadsword AFRL/IF		*40*
466	1	O	1	Information access	Protection	Recall of inaccurate information		DARPA ISO	IA	Sami Sadjari	*1*
467	1	O	1	Information access	Protection	Recall of inaccurate information		DARPA ITO	IS	Teresa Lunt	*3*
468	1	O	1	Information access	Communication	Conversational query	User expressions of information needs & possibly desired sources.	AFRL/IF	Broadsword	J. Salerno	*40*
469	1	O	1	Information access	Communication	Conversational query		DARPA/ISO	I3, JLACTD, TRIPS	Dave Gunning	*1*

	P	M	E	Technologies	Technology Area	Specific Technology	Definition/Explanation	Organization	Research Programs	Program Manager	*Internet Address Reference*
470	1	O	1	Information access	Communication	Conversational query	User expressions of information needs & possibly desired sources.	NSF	Visual Query Languages for Database Systems		*24*
471	1	O	1	Information access	Communication	Conversational query		AFRL/HE		T. Andersen	*47*
472	1	O	1	Information access	Communication	Conversational query		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
473	1	O	1	Information access	Communication	Conversational query		DARPA ISO	DMIF	Stephen Flank	*1*
474	1	O	1	Information access	Communication	Conversational query		DARPA ISO	AIM	Carol Thompson	*1*
475	1	O	1	Information access	Communication	Conversational query		DARPA ISO	GENOA	Brian Sharkey	*1*
476	1	O	1	Information access	Communication	Conversational query		DARPA ISO	CPOF	Dave Gunning	*4*
477	1	O	1	Information access	Communication	Conversational query		DARPA ISO	COABS	Doug Dyer	*1*
478	1	O	1	Information access	Communication	Conversational query		DARPA ISO	ALP	Todd Carrico	*1*
479	1	O	1	Information access	Communication	Conversational query		DARPA ISO	JFACC	Daniel McCrory	*1*
480	1	G	2	Information access	Communication	Speech	Translations of vocalized expressions.	AFRL/IF	Audio Processing	J. Cupples	*39*
481	1	G	2	Information access	Communication	Speech		NASA	Data Entry Device		*25*
482	1	G	2	Information access	Communication	Speech		FAA	Impact of Speech Dysfluencies		*26*
483	1	G	2	Information access	Communication	Speech		AFRL/HE		D. Williamson	*47*
484	1	G	2	Information access	Communication	Speech		DARPA/IT	Communicator	A. Sears	*3*
485	1	G	2	Information access	Communication	Speech		SSC-SD		G. Dean	*41*
486	1	G	2	Information access	Communication	Speech		DARPA ISO	CPOF	Dave Gunning	*4*
487	1	G	2	Information access	Communication	Speech		DARPA ISO	TVRS	Allen Sears	*1*
488	1	O	2	Information access	Communication	Natural language	Translations of natural language expressions.	AFRL/IF	HPKB	C. Anken	*44*
489	1	O	2	Information access	Communication	Natural language		AFRL/IF	Information Exploitation Technology	C. Pine	*39*
490	1	O	2	Information access	Communication	Natural language		AFRL/IF		J. Smith	*39*
491	1	O	2	Information access	Communication	Natural language		DARPA/ITO	HLS	A. Sears	*3*
492	1	O	2	Information access	Communication	Natural language		NSF	Interactive Processes of Language Z Use in Human-Computer Interfaces		*27*
493	1	O	2	Information access	Communication	Natural language		AFRL/HE		T. Andersen	*n/a*
494	1	O	2	Information access	Communication	Natural language		DARPA/IT	Communicator	A. Sears	*3*
495	1	O	2	Information access	Communication	Natural language		DARPA ISO	CPOF	Dave Gunning	*4*
496	1	O	2	Information access	Communication	Natural language		DARPA ISO	COABS	Doug Dyer	*1*
497	1	O	2	Information access	Communication	Natural language		DARPA ISO	GENOA	Brian Sharkey	*1*
498	1	O	2	Information access	Communication	Natural language		DARPA ISO	TVRS	Allen Sears	*1*

	P	M	E	Technologies	Technology Area	Specific Technology	Definition/Explanation	Organization	Research Programs	Program Manager	*Internet Address Reference*
499	2	B	2	Information access	Communication	Annotation	Attachment of explanations & caveats to expressions by users & others.	NSF	Speech Generation for Human-Computer Interaction		*28*
500	2	B	2	Information access	Communication	Annotation		AFRL/HE		T. Andersen	*47*
501	2	B	2	Information access	Communication	Annotation		DARPA ISO	TVRS	Allen Sears	*1*
502	2	O	3	Information access	Communication	Domain-specific gesturing	Translations of gestural expressions.	AFRL/IF			*39*
503	2	O	3	Information access	Communication	Domain-specific gesturing		DARPA/ITO	Communicator	A. Sears	*3*
504	2	O	3	Information access	Communication	Domain-specific gesturing		NSF	A Unified Framework for Multimodal Conversational Behaviors in Interactive Humanoid Agents		*29*
505	2	O	3	Information access	Communication	Domain-specific gesturing		NSF	A Gesture Interpretation & Voice Recognition Multi-Modal Human Machine Interface		*30*
506	2	O	3	Information access	Communication	Domain-specific gesturing		NASA	Virtual Spacetime		*31*
507	2	O	3	Information access	Communication	Domain-specific gesturing		AFRL/HE		G. McMillan	*n/a*
508	2	O	3	Information access	Communication	Domain-specific gesturing		DARPA/IS	CPOF		*4*
509	2	O	3	Information access	Communication	Domain-specific gesturing		AFOSR		T. Poggio	*45*
510	2	O	3	Information access	Communication	Domain-specific gesturing		AFOSR		S. Zucker	*48*
511	2	O	3	Information access	Communication	Domain-specific gesturing		SSC-SD		G. Osaga	*41*
512	2	O	3	Information access	Communication	Domain-specific gesturing		DARPA ISO	TVRS	Allen Sears	*1*
513	1	G	1	Information access	Collaboration	Sharing	Interaction via shared representations of information.	AFRL/IF	EDCS	C. Burns	*39*
514	1	G	1	Information access	Collaboration	Sharing		AFRL/IF		C. DeFranco	*39*
515	1	G	1	Information access	Collaboration	Sharing		AFRL/IF	Virtual Environments	A. Sisti	*39*
516	1	G	1	Information access	Collaboration	Sharing		RL	AFRL Collaborative Enterprise Technology	B. McQuay	*39*
517	1	G	1	Information access	Collaboration	Sharing		NASA	The Bluecoat Project		*32*
518	1	G	1	Information access	Collaboration	Sharing		NASA	Team Decision Making		*33*
519	1	G	1	Information access	Collaboration	Sharing		SPAWAR	Project IRUS		*41*
520	1	G	1	Information access	Collaboration	Sharing		AFRL/HE		M. Haas	*47*
521	1	G	1	Information access	Collaboration	Sharing		DARPA/IS	C2 Programs		*1*
522	1	G	1	Information access	Collaboration	Sharing		SSC-SD		L. Duffy	*41*
523	1	G	1	Information access	Collaboration	Sharing		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
524	1	G	1	Information access	Collaboration	Sharing		DARPA ISO	JFACC	Daniel McCrory	*1*
525	1	G	1	Information access	Collaboration	Sharing		DARPA ISO	GENOA	Brian Sharkey	*1*

	P	M	E	Technologies	Technology Area	Specific Technology	Definition/Explanation	Organization	Research Programs	Program Manager	*Internet Address Reference*
526	1	G	1	Information access	Collaboration	Sharing	Interaction via shared representations of information.	DARPA ISO	CPOF	Dave Gunning	*4*
527	1	G	1	Information access	Collaboration	Sharing		DARPA ISO	DMIF	Stephen Flank	*1*
528	1	G	1	Information access	Collaboration	Sharing		DARPA ISO	COABS	Doug Dyer	*1*
529	1	G	1	Information access	Collaboration	Sharing		DARPA ISO	AIM	Carol Thompson	*1*
530	1	G	1	Information access	Collaboration	Sharing		DARPA ITO	EDCS	John Salasin	*3*
531	1	B	1	Information access	Collaboration	Advanced whiteboarding	Creation & sharing explanations & summaries of information.	AFRL/IF		C. DeFranco	*39*
532	1	B	1	Information access	Collaboration	Advanced whiteboarding		AFRL/IF		A. Sisti	*39*
533	1	B	1	Information access	Collaboration	Advanced whiteboarding		AFRL/IF		B. McQuay	*39*
534	1	B	1	Information access	Collaboration	Advanced whiteboarding		DARPA/IT	CI&V	K. Mills	*3*
535	1	B	1	Information access	Collaboration	Advanced whiteboarding		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
536	1	B	1	Information access	Collaboration	Advanced whiteboarding		DARPA ISO	JFACC	Daniel McCrory	*1*
537	1	B	1	Information access	Collaboration	Advanced whiteboarding		DARPA ISO	GENOA	Brian Sharkey	*1*
538	1	B	1	Information access	Collaboration	Advanced whiteboarding		DARPA ISO	CPOF	Dave Gunning	*4*
539	1	B	1	Information access	Collaboration	Advanced whiteboarding		DARPA ISO	DMIF	Stephen Flank	*1*
540	1	B	1	Information access	Collaboration	Advanced whiteboarding		DARPA ITO	EDCS	John Salasin	*3*
541	2	O	1	Information access	Collaboration	Domain-specific workflow management	Mgt. of allocation of tasks, information, & decisions among participants.	AFRL/IF	ARPI	R. Metzger	*42*
542	2	O	1	Information access	Collaboration	Domain-specific workflow management		AFRL/IF		C. DeFranco	*39*
543	2	O	1	Information access	Collaboration	Domain-specific workflow management		AFRL/IF	Virtual Environments	A. Sisti	*39*
544	2	O	1	Information access	Collaboration	Domain-specific workflow management		AFRL/IF		B. McQuay	*39*
545	2	O	1	Information access	Collaboration	Domain-specific workflow management		AFOSR		M. Just	*43*
546	2	O	1	Information access	Collaboration	Domain-specific workflow management		SSC-SD		J. Clarkson	*41*
547	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ISO	PDA	Doug Dyer	*1*
548	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ISO	JFACC	Daniel McCrory	*1*
549	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ISO	GENOA	Brian Sharkey	*1*
550	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ISO	ALP	Todd Carrico	*1*
551	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ISO	AIM	Carol Thompson	*1*
552	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ISO	DMIF	Stephen Flank	*1*
553	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ISO	CPOF	Dave Gunning	*4*
554	2	O	1	Information access	Collaboration	Domain-specific workflow management		DARPA ITO	EDCS	John Salasin	*3*
555	2	O	1	Information access	Collaboration	Mixed initiatives	Human/machine partnership in problem solving.	DARPA/ISO	TRIPS	Doug Dyer	*n/a*
556	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
557	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	DMIF	Stephen Flank	*1*
558	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	COABS	Doug Dyer	*1*
559	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	ALP	Todd Carrico	*1*

	P	M	E	Technologies	Technology Area	Specific Technology	Definition/Explanation	Organization	Research Programs	Program Manager	*Internet Address Reference*
560	2	O	1	Information access	Collaboration	Mixed initiatives	Human/machine partnership in problem solving.	DARPA ISO	AIM	Carol Thompson	*1*
561	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	SAIP	Stephen Welby	*1*
562	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	MSTAR	Robert Hummel	*1*
563	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA STO	MTE	Bruce Johnson	*37*
564	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	DDB		*1*
565	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	JFACC	Daniel McCrory	*1*
566	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	GENOA	Brian Sharkey	*1*
567	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	HPKB	Dave Gunning	*1*
568	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	PDA	Doug Dyer	*1*
569	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	CPOF	Dave Gunning	*4*
570	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ITO	EDCS	John Salasin	*3*
571	2	O	1	Information access	Collaboration	Mixed initiatives		DARPA ISO	COAA	Dell Lunceford	*1*
572	2	B	3	Information access	Collaboration	Facilitation	Support of group processes for discussion, decision making, etc.	AFRL/IF		C. Burns	*39*
573	2	B	3	Information access	Collaboration	Facilitation		AFRL/IF		C. DeFranco	*39*
574	2	B	3	Information access	Collaboration	Facilitation		AFRL/IF	Virtual Environments	A. Sisti	*39*
575	2	B	3	Information access	Collaboration	Facilitation		AFRL/IF		B. McQuay	*39*
576	2	B	3	Information access	Collaboration	Facilitation		NSF	Group Decision Making & Group Decision Support Systems		*34*
577	2	B	3	Information access	Collaboration	Facilitation		AFRL/HE		M. Haas	*47*
578	2	B	3	Information access	Collaboration	Facilitation		DARPA/IT	CI&V	K. Mills	*3*
579	2	B	3	Information access	Collaboration	Facilitation		SSC-SD		L. Duffy	*41*
580	2	B	3	Information access	Collaboration	Facilitation		DARPA ISO	JTF-ATD	Ref Dellgado	*1*
581	2	B	3	Information access	Collaboration	Facilitation		DARPA ISO	GENOA	Brian Sharkey	*1*
582	2	B	3	Information access	Collaboration	Facilitation		DARPA ISO	CPOF	Dave Gunning	*4*
583	2	B	3	Information access	Collaboration	Facilitation		DARPA ISO	JFACC	Daniel McCrory	*1*
584	2	B	3	Information access	Collaboration	Facilitation		DARPA ITO	EDCS	John Salasin	*3*

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BMDO	Ballistic Missile Defense Office

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– EN	- Directorate of Engineering and Technical Management
– AFRL	- Air Force Research Laboratory
– SMC	- Space and Missile Systems Center
– ESC	- Electronic Systems Center
– ASC	- Aeronautics Systems Center
– HSC	- Human Systems Center
– AFOSR	- Air Force Office of Scientific Research
ACC	Air Combat Command
– CC	- Commander, Air Combat Command
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AMC	Air Mobility Command
AFSPC	Air Force Space Command
PACAF	Pacific Air Forces
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13. ABSTRACT (Maximum 200 Words)
This report summarizes the deliberations and conclusions of the 1998 Air Force Scientific Advisory Board (SAB) study on *Information Management to Support the Warrior*. In the study, the panel develops an enhanced concept for managing information for all echelons of command. A combination of continuing and leveraging the current information management programs/investment and overlaying the concept of Battlespace InfoSphere (BI) are identified in the report. The Air Force needs to get the right information at the right time disseminated and displayed in the right way so commanders and "crew chiefs" can do the right thing at the right time the right way. The information must be provided without creating an information blizzard. When the Air Force does this faster than the adversary, the Air Force has information superiority. The emphasis of this panel was developing a BI concept for managing the information. The BI is the next step in the evolution from system-centric to network-centric through information-centric. The BI must support all levels of military operations, such as command, planning, execution, information support, combat support, anywhere, anytime, from a distributed base of operations. Information management processes enable the input, manipulation, and access of information. The major technologies and associated research/development projects at agencies throughout the government are sorted according to a variety of prioritization schemes. The panel sorted according to the following schemes: Air force priority, maturity, evolution, and capability of the technologies. Finally, the panel recommends that the Air Force implement the BI concept.

14. SUBJECT TERMS
ACTD, battlespace, Battlespace InfoSphere, $C^4$1, command and control, decision support tools, combat support, data fusion, fuselet, battlespace awareness, information access, information grid, information management, information manipulation, network-centric, sensors

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